



2013 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM)

October 2015
Final Report

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By:
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Morrisville, NC 27560

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U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Contract No. EP-D-09-048
Delivery Orders 46, 47, 48, 52, 55, 56, 60, 61, 62, & 63

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Assessment Division
Research Triangle Park, NC 27711

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DISCLAIMER

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LIST OF ACRONYMS

AADT	Annual Average Daily Traffic
AGL	Above Ground Level
AQS	Air Quality System
ASE	Accelerated Solvent Extractor
ATSDR	Agency for Toxic Substances and Disease Registry
CBSA	Core-Based Statistical Area(s)
CFR	Code of Federal Regulations
CNG	Compressed Natural Gas
CSATAM	Community-Scale Air Toxics Ambient Monitoring
CV	Coefficient of Variation
DNPH	2,4-Dinitrophenylhydrazine
DQI	Data Quality Indicator(s)
DQO	Data Quality Objective(s)
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group, Inc.
F	Fahrenheit
FAC	Federal Advisory Committee
FEM	Federal Equivalent Method
FHWA	Federal Highway Administration
GC/MS-FID	Gas Chromatography/Mass Spectrometry and Flame Ionization Detection
GHG	Greenhouse Gas(es)
GIS	Geographical Information System
GMT	Greenwich Mean Time
GWP	Global Warming Potential
HAP	Hazardous Air Pollutant(s)
HPLC	High-Performance Liquid Chromatography
HQ	Hazard Quotient
IC	Ion Chromatography
ICP-MS	Inductively Coupled Plasma/Mass Spectrometry
IPCC	Intergovernmental Panel on Climate Change
kt	Knots
mb	Millibar
MDL	Method Detection Limit
mg/m ³	Milligrams per cubic meter
mL	Milliliter
MQO	Measurement Quality Objective(s)
MRL	Minimal Risk Level
NAAQS	National Ambient Air Quality Standard
NATA	National-Scale Air Toxics Assessment
NATTS	National Air Toxics Trends Stations
NCDC	National Climatic Data Center
ND	Non-detect

LIST OF ACRONYMS (Continued)

NEI	National Emissions Inventory
ng/m ³	Nanograms per cubic meter
NMOC	Non-Methane Organic Compound(s)
NMP	National Monitoring Programs
NOAA	National Oceanic and Atmospheric Administration
NO _x	Oxides of Nitrogen
NWS	National Weather Service
PAH	Polycyclic Aromatic Hydrocarbon(s)
PAMS	Photochemical Assessment Monitoring Stations
PM	Particulate Matter
PM ₁₀	Particulate Matter less than 10 microns
POM	Polycyclic Organic Matter
ppbC	Parts per billion carbon
ppbv	Parts per billion by volume
ppm	Parts per million
PT	Proficiency Test
PUF	Polyurethane Foam
QAPP	Quality Assurance Project Plan
RfC	Reference Concentration(s)
SATMP	School Air Toxics Monitoring Program
SIM	Selected Ion Monitoring
SIP	State Implementation Plan(s)
SNMOC	Speciated Nonmethane Organic Compound(s)
TAD	Technical Assistance Document
TNMOC	Total Nonmethane Organic Compound(s)
tpy	Tons per year
TSP	Total Suspended Particulate
UATMP	Urban Air Toxics Monitoring Program
µg/m ³	Micrograms per cubic meter
µL	Microliter
URE	Unit Risk Estimate(s)
UTC	Universal Time Coordinated
UV	Ultraviolet
UV-VIS	Ultraviolet Visible
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound(s)
WBAN	Weather Bureau/Army/Navy ID

Abstract

This report presents the results and conclusions from the ambient air monitoring conducted as part of the 2013 National Monitoring Programs (NATTS, UATMP, and CSATAM) - three individual programs with different goals, but together result in a better understanding and appreciation of the nature and extent of toxic air pollution. The 2013 NMP includes data from samples collected at 66 monitoring sites that collected 24-hour air samples, typically on a 1-in-6 or 1-in-12 day schedule. Thirty-four sites sampled for 59 volatile organic compounds (VOCs); 33 sites sampled for 15 carbonyl compounds; seven sites sampled for 80 speciated nonmethane organic compounds (SNMOCs); 24 sites sampled for 22 polycyclic aromatic hydrocarbons (PAHs) and one additional site sampled for a subset of PAHs and four phenols; 20 sites sampled for 11 metals; and 24 sites sampled for hexavalent chromium. Nearly 263,000 ambient air concentrations were measured during the 2013 NMP. This report uses various graphical, numerical, and statistical analyses to put the vast amount of ambient air monitoring data collected into perspective. Not surprisingly, the ambient air concentrations measured during the program varied from city-to-city and from season-to-season.

The ambient air monitoring data collected during the 2013 NMP serve a wide range of purposes. Not only do these data allow for the characterization of the nature and extent of air pollution close to the 66 individual monitoring sites participating in these programs, but they also exhibit trends and patterns that may be common to urban and rural environments and across the country. Therefore, this report presents results that are specific to particular monitoring locations and presents other results that are common to all environments. The results presented provide additional insight into the complex nature of air pollution. The raw data are included in the appendices of this report.

1.0 Introduction

Air pollution contains many components that originate from a wide range of stationary, mobile, and natural emissions sources. Because some of these components include air toxics that are known or suspected to have the potential for negative human health effects, the U.S. Environmental Protection Agency (EPA) encourages state, local, and tribal agencies to understand and appreciate the nature and extent of toxic air pollution in their respective locations. To achieve this goal, EPA sponsors the National Monitoring Programs (NMP), which include the Photochemical Assessment Monitoring Stations (PAMS) network, Urban Air Toxics Monitoring Program (UATMP), National Air Toxics Trends Stations (NATTS) network, Community-Scale Air Toxics Ambient Monitoring (CSATAM) Program, and monitoring for other pollutants such as Non-Methane Organic Compounds (NMOCs). The UATMP, the NATTS, and the CSATAM programs include longer-term monitoring efforts (durations of one year or more) at specific locations. These programs have the following program-specific objectives (EPA, 2009a):

- The primary objective of the UATMP is to characterize the composition and magnitude of air toxics pollution through ambient air monitoring.
<http://www.epa.gov/ttnamti1/uatm.html>
- The primary objective of the NATTS network is to obtain a statistically significant quantity of high-quality representative air toxics measurements such that long-term trends can be identified. <http://www.epa.gov/ttnamti1/natts.html>
- The primary objective of the CSATAM Program is to conduct local-scale investigative ambient air toxics monitoring projects.
<http://www.epa.gov/ttnamti1/local.html>

1.1 Background

The UATMP was initiated by EPA to meet the increasing need for information on air toxics. Over the years, the program has grown in both participation and targeted pollutants (EPA, 2009a). The program has allowed for the identification of compounds that are prevalent in ambient air and for participating agencies to screen air samples for concentrations of air toxics that could potentially result in adverse human health effects.

The NATTS network was created to generate long-term ambient air toxics concentration data at specific fixed sites across the country. The 10-City Pilot Program (LADCO, 2003) was developed and implemented during 2001 and 2002, leading to the development and initial

implementation of the NATTS network during 2003 and 2004. The goal of the program is to estimate the concentrations of air toxics on a national level from fixed sites that remain active over an extended period of time such that concentration trends (i.e., any substantial increase or decrease over a period of time) may be identified. The data generated are also used for validating modeling results and emissions inventories, assessing current regulatory benchmarks, and assessing the potential for developing cancerous and noncancerous health effects (EPA, 2014a). The initial site locations were based on existing infrastructure of monitoring site locations (e.g., PM_{2.5} network) and results from preliminary air toxics programs such as the 1996 National-Scale Air Toxics Assessment (NATA), which used air toxics emissions data to model ambient monitoring concentrations across the nation. Monitoring sites were placed in both urban and rural locations. Urban areas were chosen to measure population exposure, while rural areas were chosen to determine background levels of air pollution and to assess impacts to non-urban areas (EPA, 2009b). Currently, 27 NATTS sites are strategically placed across the country (EPA, 2014a).

The CSATAM Program was initiated in 2004 and is intended to support state, local, and tribal agencies in conducting discreet, investigative projects of approximately 2-year durations via periodic grant competitions (EPA, 2009a). The objectives of the CSATAM Program include identifying and profiling air toxics sources; developing and assessing emerging measurement methods; characterizing the degree and extent of local air toxics problems; and tracking progress of air toxics reduction activities (EPA, 2009a).

1.2 The Report

Many environmental and health agencies have participated in these programs to assess the sources, effects, and changes in air pollution within their jurisdictions. This report summarizes and interprets measurements collected at monitoring sites participating in the UATMP, NATTS, and CSATAM programs in 2013. Included in this report are data from sites whose operating agencies have opted to have their samples analyzed by EPA's national contract laboratory, Eastern Research Group, Inc. (ERG). Agencies operating sites under the NMP are not required to have their samples analyzed by ERG or may not have samples for all methods analyzed by ERG, as they may have their own laboratories or use other contract laboratories. In these cases, data are generated by sources other than ERG and are not included in this report. In

addition, a state, local, or tribal agency may opt to contract with ERG for a special air toxics monitoring study in which their data are included in the report as well.

In past reports, measurements from UATMP, NATTS, and CSATAM monitoring sites have been presented together and referred to as “UATMP sites.” In more recent reports, a distinction has been made among the three programs due to the increasing number of sites covered under each program. Thus, it is appropriate to describe each program; to distinguish among their purposes and scopes; and to integrate the data, which allows each program’s objectives and goals to complement one another.

Included in this report are data collected at 66 monitoring sites around the country. The 66 sites whose data are included in this report are located in or near 40 urban or rural locations in 25 states and the District of Columbia, including 38 metropolitan or micropolitan statistical areas (collectively referred to as core-based statistical areas or CBSAs).

This report provides both a qualitative overview of air toxics pollution at participating urban and rural locations and a quantitative data analysis of the factors that appear to most significantly affect the behavior of air toxics in urban and rural areas. This report also focuses on data characterizations for each of the 66 different air monitoring locations, a site-specific approach that allows for a much more detailed evaluation of the factors (e.g., emissions sources, natural sources, meteorological influences) that affect air quality differently from one location to the next. Much of the data analysis and interpretation contained in this report focuses on pollutant-specific risk potential.

This report offers participating agencies relevant information and insight into important air quality issues. For example, participating agencies can use trends and patterns in the monitoring data to determine whether levels of air pollution present public health concerns, to identify which emissions sources contribute most to air pollution, or to forecast whether proposed pollution control initiatives could significantly improve air quality. Monitoring data may also be compared to modeling results, such as from EPA’s NATA. Policy-relevant questions that the monitoring data may help answer include the following:

- Which anthropogenic sources substantially affect air quality?

- Have pollutant concentrations decreased as a result of regulations (or increased despite regulation)?
- Which pollutants contribute the greatest health risk on a short-term, intermediate-term, and long-term basis?

The data analyses contained in this report are applied to each participating UATMP, NATTS, or CSATAM monitoring site, depending upon pollutants sampled and duration of sampling. Although many types of analyses are presented, state and local environmental agencies are encouraged to perform additional evaluations of the monitoring data so that the many factors that affect their specific ambient air quality can be understood fully.

To facilitate examination of the 2013 UATMP, NATTS, and CSATAM monitoring data, henceforth referred to as NMP data, the complete set of measured concentrations is presented in the appendices of this report. In addition, these data are publicly available in electronic format from EPA's Air Quality System (AQS) (EPA, 2014b).

This report is organized into 33 sections and 18 appendices. While each state section is designed to be a stand-alone section to allow those interested in a particular site or state to understand the associated data analyses without having to read the entire report, it is recommended that Sections 1 through 4 (Introduction, Monitoring Programs Network overview, Data Treatments and Methods, and Summary of NMP Data) and Sections 31 and 32 (Data Quality and Results, Conclusions, and Recommendations) be read as complements to the individual state sections. Table 1-1 highlights the contents of each section.

Table 1-1. Organization of the 2013 National Monitoring Programs Report

Report Section	Section Title	Overview of Contents
1	Introduction	This section serves as an introduction to the background and scope of the NMP (specifically, the UATMP, NATTS, and CSATAM Programs).
2	The 2013 National Monitoring Programs Network	This section provides information on the 2013 NMP monitoring effort, including: <ul style="list-style-type: none"> • Monitoring locations • Pollutants selected for monitoring • Sampling and analytical methods • Sampling schedules • Completeness of the air monitoring programs.

Table 1-1. Organization of the 2013 National Monitoring Programs Report (Continued)

Report Section	Section Title	Overview of Contents
3	Summary of the 2013 National Monitoring Programs Data Treatments and Methods	This section presents and discusses the data treatments applied to the 2013 NMP data to determine significant trends and relationships in the data, characterize data based on how ambient air concentrations varied with monitoring location and with time, interpret the significance of the observed spatial and temporal variations, and evaluate human health risk.
4	Summary of the 2013 National Monitoring Programs Data	This section presents and discusses the results of the data treatments from the 2013 NMP data.
5	Site in Alaska	Monitoring results for the site in the Anchorage, AK CBSA (ANAK)
6	Sites in Arizona	Monitoring results for the sites in the Phoenix-Mesa-Scottsdale, AZ CBSA (PXSS and SPAZ)
7	Sites in California	Monitoring results for the sites in the Los Angeles-Long Beach-Anaheim, CA CBSA (CELA and LBHCA), the Riverside-San Bernardino-Ontario, CA CBSA (RUCA), and the San Jose-Sunnyvale-Santa Clara, CA CBSA (SJJCA)
8	Sites in Colorado	Monitoring results for the sites in the Grand Junction, CO CBSA (GPCO) and the Glenwood Springs, CO CBSA (BMCO, BRCO, PACO, RFCO, and RICO)
9	Site in the District of Columbia	Monitoring results for the site in the Washington-Arlington-Alexandria, DC-VA-MD-WV CBSA (WADC)
10	Sites in Florida	Monitoring results for the sites in the Miami-Fort Lauderdale-West Palm Beach, FL CBSA (WPFL), the Orlando-Kissimmee-Sanford, FL CBSA (ORFL and PAFL), and the Tampa-St. Petersburg-Clearwater, FL CBSA (AZFL, SKFL, and SYFL)
11	Site in Georgia	Monitoring results for the site in the Atlanta-Sandy Springs-Roswell, GA CBSA (SDGA)
12	Sites in Illinois	Monitoring results for the sites in the Chicago-Naperville-Elgin, IL-IN-WI CBSA (NBIL and SPIL) and the St. Louis, MO-IL CBSA (ROIL)
13	Sites in Indiana	Monitoring results for the sites in the Chicago-Naperville-Elgin, IL-IN-WI CBSA (INDEM) and the Indianapolis-Carmel-Anderson, IN CBSA (WPIN)
14	Sites in Kentucky	Monitoring results for the sites in the Huntington-Ashland, WV-KY-OH CBSA (ASKY and ASKY-M), the Lexington-Fayette, KY CBSA (LEKY), the Evansville, IN-KY CBSA (BAKY), the Paducah, KY-IL CBSA (BLKY), and the sites in Marshall County (ATKY, CCKY, LAKY, and TVKY) and Carter County (GLKY)
15	Site in Massachusetts	Monitoring results for the site in the Boston-Cambridge-Newton, MA-NH CBSA (BOMA)
16	Site in Michigan	Monitoring results for the site in the Detroit-Warren-Dearborn, MI CBSA (DEMI)

Table 1-1. Organization of the 2013 National Monitoring Programs Report (Continued)

Report Section	Section Title	Overview of Contents
17	Site in Minnesota	Monitoring results for the site in the St. Cloud, MN CBSA (STMN)
18	Sites in Mississippi	Monitoring results for the sites in the Columbus, MS CBSA (KMMS and SSMS)
19	Site in Missouri	Monitoring results for the site in the St. Louis, MO-IL CBSA (S4MO)
20	Sites in New Jersey	Monitoring results for the sites in the New York-Newark-Jersey City, NY-NJ-PA CBSA (CHNJ, ELNJ, and NBNJ) and the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD CBSA (CSNJ)
21	Sites in New York	Monitoring results for the sites in the New York-Newark-Jersey City, NY-NJ-PA CBSA (BXNY) and the Rochester, NY CBSA (ROCH)
22	Sites in Oklahoma	Monitoring results for the sites in the Tulsa, OK CBSA (TOOK, TMOK, and TROK), and the Oklahoma City, OK CBSA (ADOK, OCOK, and YUOK)
23	Site in Rhode Island	Monitoring results for the site in the Providence-Warwick, RI-MA CBSA (PRRI)
24	Site in South Carolina	Monitoring results for the site in Chesterfield County, SC (CHSC)
25	Sites in Texas	Monitoring results for the sites in the Houston-The Woodlands-Sugar Land, TX CBSA (CAMS 35) and the Marshall, TX CBSA (CAMS 85)
26	Site in Utah	Monitoring results for the site in the Ogden-Clearfield, UT CBSA (BTUT)
27	Sites in Vermont	Monitoring results for the sites in the Burlington-South Burlington, VT CBSA (BURVT and UNVT) and the Rutland, VT CBSA (RUVT)
28	Site in Virginia	Monitoring results for the site in the Richmond, VA CBSA (RIVA)
29	Site in Washington	Monitoring results for the site in the Seattle-Tacoma-Bellevue, WA CBSA (SEWA)
30	Sites in Wisconsin	Monitoring results for the sites in the Beaver Dam, WI CBSA (HOWI) and the Milwaukee-Waukesha-West Allis, WI CBSA (MIWI)
31	Data Quality	This section defines and discusses the concepts of precision and accuracy. Based on quantitative and qualitative analyses, this section comments on the precision and accuracy of the 2013 NMP ambient air monitoring data.
32	Results, Conclusions, and Recommendations	This section summarizes the most significant findings of the report and makes several recommendations for future projects that involve ambient air monitoring.
33	References	This section lists the references cited throughout the report.

2.0 The 2013 National Monitoring Programs Network

Agencies operating UATMP, NATTS, or CSATAM sites may choose to have their samples analyzed by EPA's contract laboratory, ERG, in Morrisville, North Carolina. Data from 66 monitoring sites that collected 24-hour integrated ambient air samples for up to 12 months, at 1-in-6 or 1-in-12 day sampling intervals, and sent them to ERG for analysis are included in this report. Samples were analyzed for concentrations of selected hydrocarbons, halogenated hydrocarbons, and polar compounds from canister samples for Speciated Nonmethane Organic Compounds (SNMOCs) and/or Volatile Organic Compounds (VOCs) using EPA Compendium Method TO-15, carbonyl compounds from sorbent cartridge samples using EPA Compendium Method TO-11A, polycyclic aromatic hydrocarbons (PAHs) from polyurethane foam (PUF) and XAD-2[®] resin samples and/or phenols from XAD-2[®] resin samples using EPA Compendium Method TO-13A, trace metals from filters using EPA Compendium Method IO-3.5/Federal Equivalency Methods (FEM) EQL-0512-201 and EQL-0512-202, and hexavalent chromium from sodium bicarbonate-coated filters using ASTM D7614. Section 2.2 provides additional information regarding each of the sampling methodologies used to collect and analyze samples.

Agencies operating sites under the NMP are not required to have their samples analyzed by ERG. They may have samples for only select methods analyzed by ERG, as they may have their own laboratory capabilities for other methods. In these cases, data are generated by sources other than ERG and are therefore not included in this report.

The following sections review the monitoring locations, pollutants selected for monitoring, sampling and analytical methods, collection schedules, and completeness of the 2013 NMP dataset.

2.1 Monitoring Locations

For the NATTS network, monitor siting is based on the need to assess population exposure and/or background-level concentrations. For the UATMP and CSATAM programs, representatives from the state, local, and tribal agencies that voluntarily participate in the programs select the monitoring locations based on specific siting criteria and study needs. Among these programs, monitors were placed in urban areas near the centers of heavily populated cities (e.g., Chicago, Illinois and Phoenix, Arizona), while others were placed in moderately populated rural areas (e.g., Horicon, Wisconsin and Chesterfield, South Carolina).

Figure 2-1 shows the locations of the 66 monitoring sites participating in the 2013 programs, which encompass 40 different urban and rural areas. Outlined in Figure 2-1 are the associated CBSAs, as designated by the U.S. Census Bureau, where each site is located (Census Bureau, 2013a). A CBSA refers to either a metropolitan (an urban area with 50,000 or more people) or micropolitan (an urban area with at least 10,000 people but less than 50,000 people) statistical area (Census Bureau, 2013b).

Table 2-1 lists the respective monitoring program and the years of program participation for the 66 monitoring sites. Sixty-one monitoring sites have been included in previous annual reports, including two that are returning for the first time in five or more years; these two sites are highlighted in purple in Table 2-1. Five monitoring sites are new to their respective programs for 2013; these sites are highlighted in green in Table 2-1.

As Figure 2-1 and Table 2-1 show, the 2013 NMP sites are widely distributed across the country. Detailed information about the monitoring sites is provided in Table 2-2 and Appendix A. Monitoring sites that are designated as part of the NATTS network are indicated by bold italic type in Table 2-1 and subsequent tables throughout this report in order to distinguish this program from the other programs. Table 2-2 shows that the location of the monitoring sites vary significantly. These sites are located in areas of differing elevation, population, land use, climatology, and topography. A more detailed look at each monitoring site's surroundings is provided in the individual state sections.

For record-keeping and reporting purposes, each site was assigned the following:

- A unique four, five, or six-letter site code used to track samples from the monitoring site to the ERG laboratory.
- A unique nine-digit AQS site code used to index monitoring results in the AQS database.

This report cites the four, five, or six-letter site code when presenting selected monitoring results. For reference, each site's AQS site code is provided in Table 2-2.

Figure 2-1. Locations of the 2013 National Monitoring Programs Monitoring Sites

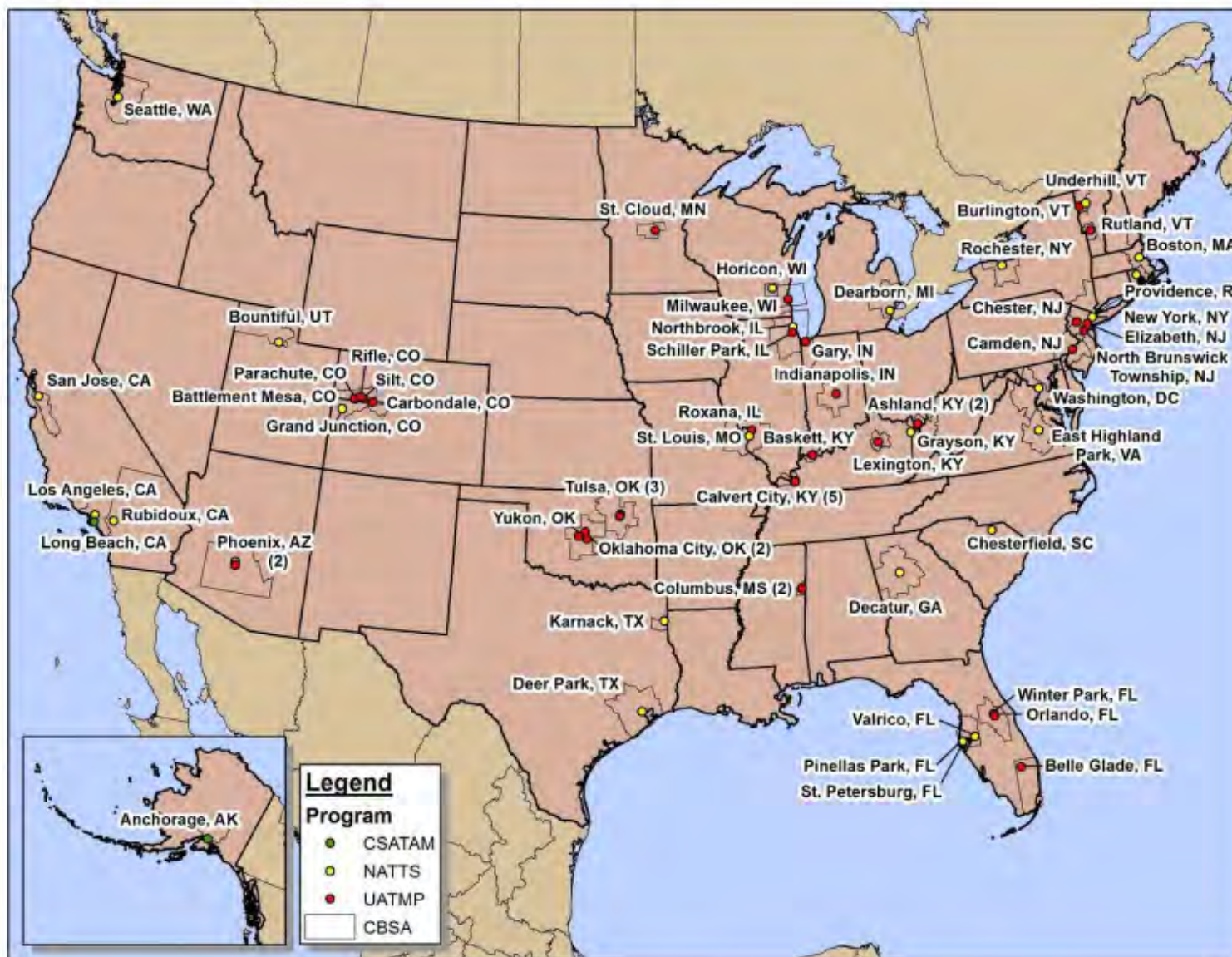


Table 2-1. 2013 National Monitoring Programs Sites and Past Program Participation

Monitoring Location and Site	Program	2003 and Earlier	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Anchorage, AK (ANAK)	CSATAM						✓					✓
Ashland, KY (ASKY)	UATMP										✓	✓
Ashland, KY (ASKY-M)	UATMP										✓	✓
Baskett, KY (BAKY)	UATMP										✓	✓
Battlement Mesa, CO (BMCO)	UATMP								✓	✓	✓	✓
Belle Glade, FL (WPFL)	UATMP	2002- 2003										✓
Boston, MA (BOMA)	NATTS	2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bountiful, UT (BTUT)	NATTS	2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Burlington, VT (BURVT)	UATMP							✓	✓	✓	✓	✓
Calvert City, KY (ATKY)	UATMP										✓	✓
Calvert City, KY (CCKY)	UATMP										✓	✓
Calvert City, KY (LAKY)	UATMP										✓	✓
Calvert City, KY (TVKY)	UATMP										✓	✓
Camden, NJ (CSNJ)	UATMP											✓
Carbondale, CO (RFCO)	UATMP										✓	✓
Chester, NJ (CHNJ)	UATMP	2001- 2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chesterfield, SC (CHSC)	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓

Green shading indicates new site participating in the NMP.

Purple shading indicates returning site with past NMP participation.

BOLD ITALICS = EPA-designated NATTS site

Table 2-1. 2013 National Monitoring Programs Sites and Past Program Participation (Continued)

Monitoring Location and Site	Program	2003 and Earlier	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Columbus, MS (KMMS)	UATMP											✓
Columbus, MS (SMMS)	UATMP											✓
Dearborn, MI (<i>DEMI</i>)	NATTS	2001- 2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Decatur, GA (<i>SDGA</i>)	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓
Deer Park, TX (<i>CAMS 35</i>)	NATTS					✓	✓	✓	✓	✓	✓	✓
East Highland Park, VA (<i>RIVA</i>)	NATTS						✓	✓	✓	✓	✓	✓
Elizabeth, NJ (ELNJ)	UATMP	1999-2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Gary, IN (INDEM)	UATMP		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Grand Junction, CO (<i>GPCO</i>)	NATTS		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Grayson, KY (<i>GLKY</i>)	NATTS						✓	✓	✓	✓	✓	✓
Horicon, WI (<i>HOWI</i>)	NATTS								✓	✓	✓	✓
Indianapolis, IN (WPIN)	UATMP				✓	✓	✓	✓	✓	✓	✓	✓
Karnack, TX (<i>CAMS 85</i>)	NATTS					✓			✓	✓	✓	✓
Lexington, KY (LEKY)	UATMP										✓	✓
Long Beach, CA (LBHCA)	CSATAM										✓	✓
Los Angeles, CA (CELA)	NATTS					✓	✓	✓	✓	✓	✓	✓
Milwaukee, WI (MIWI)	UATMP										✓	✓

Green shading indicates new site participating in the NMP.

Purple shading indicates returning site with past NMP participation.

BOLD ITALICS = EPA-designated NATTS site

Table 2-1. 2013 National Monitoring Programs Sites and Past Program Participation (Continued)

Monitoring Location and Site	Program	2003 and Earlier	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
New York, NY (<i>BXNY</i>)	NATTS				✓	✓	✓	✓	✓		✓	✓
North Brunswick, NJ (NBNJ)	UATMP	2001- 2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Northbrook, IL (<i>NBIL</i>)	NATTS	2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Oklahoma City, OK (ADOK)	UATMP										✓	✓
Oklahoma City, OK (OCOK)	UATMP							✓	✓	✓	✓	✓
Orlando, FL (PAFL)	UATMP						✓	✓	✓	✓	✓	✓
Parachute, CO (PACO)	UATMP						✓	✓	✓	✓	✓	✓
Phoenix, AZ (<i>PXSS</i>)	NATTS	2001- 2003	✓		✓	✓	✓	✓	✓	✓	✓	✓
Phoenix, AZ (SPAZ)	UATMP	2001				✓	✓	✓	✓	✓	✓	✓
Pinellas Park, FL (<i>SKFL</i>)	NATTS		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Providence, RI (<i>PRRI</i>)	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓
Rifle, CO (RICO)	UATMP						✓	✓	✓	✓	✓	✓
Rochester, NY (<i>ROCH</i>)	NATTS				✓	✓	✓	✓	✓	✓	✓	✓
Roxana, IL (ROIL)	Special Study										✓	✓
Rubidoux, CA (RUCA)	NATTS					✓	✓	✓	✓	✓	✓	✓
Rutland, VT (RUVT)	UATMP	1995-1999, 2002						✓	✓	✓	✓	✓
San Jose, CA (SJJCA)	NATTS						✓	✓	✓	✓	✓	✓

Green shading indicates new site participating in the NMP.

Purple shading indicates returning site with past NMP participation.

BOLD ITALICS = EPA-designated NATTS site

Table 2-1. 2013 National Monitoring Programs Sites and Past Program Participation (Continued)

Monitoring Location and Site	Program	2003 and Earlier	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Schiller Park, IL (SPIL)	UATMP	2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Seattle, WA (<i>SEWA</i>)	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓
Silt, CO (BRCO)	UATMP						✓	✓	✓	✓	✓	✓
Smithland, KY (BLKY)	UATMP										✓	✓
St. Cloud, MN (STMN)	UATMP										✓	✓
St. Louis, MO (<i>S4MO</i>)	NATTS	2002, 2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
St. Petersburg, FL (AZFL)	UATMP	1991-1992, 2001-2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tulsa, OK (TMOK)	UATMP							✓	✓	✓	✓	✓
Tulsa, OK (TOOK)	UATMP				✓	✓	✓	✓	✓	✓	✓	✓
Tulsa, OK (TROC)	UATMP											✓
Underhill, VT (<i>UNVT</i>)	NATTS	2002		✓	✓	✓	✓	✓	✓	✓	✓	✓
Valrico, FL (<i>SYFL</i>)	NATTS		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Washington, D.C. (<i>WADC</i>)	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓
Winter Park, FL (ORFL)	UATMP	1990-1991, 2003	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Yukon, OK (YUOK)	UATMP											✓

Green shading indicates new site participating in the NMP.

Purple shading indicates returning site with past NMP participation.

BOLD ITALICS = EPA-designated NATTS site

Table 2-2. Site Characterizing Information for the 2013 National Monitoring Programs Sites

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population ^a	County-level Vehicle Registration, # of Vehicles ^b (Year)	Estimated Daily Traffic, AADT ^b (Year)	County-level Stationary Source HAP Emissions ^c (tpy)	County-level Mobile Source HAP Emissions ^c (tpy)
ADOK	40-109-0042	Oklahoma City, OK	Commercial	Urban/City Center	755,245	835,642 (2013)	34,700 (2012)	2,156.08	3,425.17
ANAK	02-020-0018	Anchorage, AK	Residential	Suburban	300,950	358,999 (2013)	20,193 (2012)	684.58	2,749.31
ASKY	21-019-0017	Ashland, KY	Residential	Suburban	48,886	39,196 (2013)	7,230 (2011)	262.71	172.53
ASKY-M	21-019-0002	Ashland, KY	Industrial	Urban/City Center	48,886	39,196 (2013)	12,842 (2012)	262.71	172.53
ATKY	21-157-0016	Calvert City, KY	Industrial	Suburban	31,107	30,254 (2013)	3,262 (2012)	1,119.74	476.37
AZFL	12-103-0018	St. Petersburg, FL	Residential	Suburban	929,048	879,683 (2013)	42,500 (2013)	2,132.17	3,217.48
BAKY	21-101-0014	Baskett, KY	Commercial	Rural	46,347	38,811 (2013)	922 (2012)	397.98	268.40
BLKY	21-139-0004	Smithland, KY	Agricultural	Rural	9,359	8,338 (2013)	2,510 (2013)	32.24	136.07
BMCO	08-045-0019	Battlement Mesa, CO	Commercial	Suburban	57,302	74,036 (2012)	1,880 (2014)	3,787.70	327.61
BOMA	25-025-0042	Boston, MA	Commercial	Urban/City Center	755,503	410,436 (2014)	27,654 (2010)	851.81	1,015.72
BRCO	08-045-0009	Silt, CO	Agricultural	Rural	57,302	74,036 (2012)	1,182 (2014)	3,787.70	327.61
BTUT	49-011-0004	Bountiful, UT	Residential	Suburban	322,094	274,716 (2013)	130,950 (2012)	1,163.85	930.74
BURVT	50-007-0014	Burlington, VT	Commercial	Urban/City Center	159,515	172,203 (2013)	14,200 (2009)	432.40	477.55

BOLD ITALICS = EPA-designated NATTS site

^aReference: Census Bureau, 2014

^bIndividual references provided in each state section.

^cReference: 2011 NEI version 2 (EPA, 2015a)

^dThe proportion of county-level population to the state-level population was applied to state-level vehicle registration figure and used as a surrogate when county-level vehicle registration counts were not available.

^eGPCO's hexavalent chromium monitor is at a separate, but adjacent, location; thus, this site has two AQS codes.

^fS4MO's county-level population and vehicle registration are the sum of the county- and city-level data.

Table 2-2. Site Characterizing Information for the 2013 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population ^a	County-level Vehicle Registration, # of Vehicles ^b (Year)	Estimated Daily Traffic, AADT ^b (Year)	County-level Stationary Source HAP Emissions ^c (tpy)	County-level Mobile Source HAP Emissions ^c (tpy)
<i>BXNY</i>	36-005-0110	New York, NY	Residential	Urban/City Center	1,418,733	254,752 (2013)	98,899 (2012)	3,796.74	840.39
<i>CAMS 35</i>	48-201-1039	Deer Park, TX	Residential	Urban/City Center	4,336,853	3,401,957 (2013)	31,043 (2004)	13,524.71	8,643.58
<i>CAMS 85</i>	48-203-0002	Karnack, TX	Agricultural	Rural	66,886	72,689 (2013)	1,250 (2012)	879.41	346.43
CCKY	21-157-0018	Calvert City, KY	Residential	Suburban	31,107	30,254 (2013)	4,050 (2013)	1,119.74	476.37
<i>CELA</i>	06-037-1103	Los Angeles, CA	Residential	Urban/City Center	10,017,068	7,609,517 (2013)	231,000 (2013)	21,804.55	14,773.30
CHNJ	34-027-3001	Chester, NJ	Agricultural	Rural	499,397	443,969 (Ratio) ^d	11,215 (2012)	680.93	1,278.46
<i>CHSC</i>	45-025-0001	Chesterfield, SC	Forest	Rural	46,197	41,728 (2013)	700 (2013)	166.35	206.82
CSNJ	34-007-0002	Camden, NJ	Industrial	Urban/City Center	512,854	458,294 (Ratio) ^d	3,231 (2012)	577.27	953.66
<i>DEMI</i>	26-163-0033	Dearborn, MI	Industrial	Suburban	1,775,273	1,335,516 (2013)	94,600 (2013)	7,118.74	4,563.35
ELNJ	34-039-0004	Elizabeth, NJ	Industrial	Suburban	548,256	485,427 (Ratio) ^d	250,000 (2006)	814.19	1,017.46
<i>GLKY</i>	21-043-0500	Grayson, KY	Residential	Rural	27,202	25,487 (2013)	303 (2012)	75.96	145.24
<i>GPCO^e</i>	08-077-0017 08-077-0018	Grand Junction, CO	Commercial	Urban/City Center	147,554	176,969 (2012)	11,000 (2013)	659.65	664.73
<i>HOWI</i>	55-027-0001	Horicon, WI	Agricultural	Rural	88,344	99,078 (2013)	5,100 (2011)	429.32	458.47

BOLD ITALICS = EPA-designated NATTS site

^aReference: Census Bureau, 2014

^bIndividual references provided in each state section.

^cReference: 2011 NEI version 2 (EPA, 2015a)

^dThe proportion of county-level population to the state-level population was applied to state-level vehicle registration figure and used as a surrogate when county-level vehicle registration counts were not available.

^eGPCO's hexavalent chromium monitor is at a separate, but adjacent, location; thus, this site has two AQS codes.

^fS4MO's county-level population and vehicle registration are the sum of the county- and city-level data.

Table 2-2. Site Characterizing Information for the 2013 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population ^a	County-level Vehicle Registration, # of Vehicles ^b (Year)	Estimated Daily Traffic, AADT ^b (Year)	County-level Stationary Source HAP Emissions ^c (tpy)	County-level Mobile Source HAP Emissions ^c (tpy)
INDEM	18-089-0022	Gary, IN	Industrial	Urban/City Center	491,456	425,854 (2013)	34,754 (2011)	1,603.10	1,607.33
KMMS	28-087-0002	Columbus, MS	Residential	Urban/City Center	59,922	54,826 (2013)	9,900 (2013)	1,385.56	260.29
LAKY	21-157-0019	Calvert City, KY	Residential	Suburban	31,107	30,254 (2013)	1,189 (2012)	1,119.74	476.37
LBHCA	06-037-4002	Long Beach, CA	Residential	Suburban	10,017,068	7,609,517 (2013)	285,000 (2013)	21,804.55	14,773.30
LEKY	21-067-0012	Lexington, KY	Residential	Suburban	308,428	208,983 (2013)	10,083 (2012)	764.77	1,116.04
MIWI	55-079-0026	Milwaukee, WI	Commercial	Urban/City Center	956,023	641,582 (2013)	12,400 (2013)	2,903.89	1,966.31
<i>NBIL</i>	17-031-4201	Northbrook, IL	Residential	Suburban	5,240,700	2,074,419 (2014)	115,700 (2013)	15,663.06	8,882.46
NBNJ	34-023-0006	North Brunswick, NJ	Agricultural	Rural	828,919	734,425 (Ratio) ^d	110,653 (2009)	1,038.26	1,577.17
OCOK	40-109-1037	Oklahoma City, OK	Residential	Suburban	755,245	835,642 (2013)	41,500 (2012)	2,156.08	3,425.17
ORFL	12-095-2002	Winter Park, FL	Commercial	Urban/City Center	1,225,267	1,181,540 (2013)	29,500 (2013)	2,774.25	4,121.46
PACO	08-045-0005	Parachute, CO	Residential	Urban/City Center	57,302	74,036 (2012)	15,000 (2013)	3,787.70	327.61
PAFL	12-095-1004	Orlando, FL	Commercial	Suburban	1,225,267	1,181,540 (2013)	49,000 (2013)	2,774.25	4,121.46
PRRI	44-007-0022	Providence, RI	Residential	Urban/City Center	628,600	511,015 (Ratio) ^d	136,800 (2009)	1,362.28	1,350.29

BOLD ITALICS = EPA-designated NATTS site

^aReference: Census Bureau, 2014

^bIndividual references provided in each state section.

^cReference: 2011 NEI version 2 (EPA, 2015a)

^dThe proportion of county-level population to the state-level population was applied to state-level vehicle registration figure and used as a surrogate when county-level vehicle registration counts were not available.

^eGPCO's hexavalent chromium monitor is at a separate, but adjacent, location; thus, this site has two AQS codes.

^fS4MO's county-level population and vehicle registration are the sum of the county- and city-level data.

Table 2-2. Site Characterizing Information for the 2013 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population ^a	County-level Vehicle Registration, # of Vehicles ^b (Year)	Estimated Daily Traffic, AADT ^b (Year)	County-level Stationary Source HAP Emissions ^c (tpy)	County-level Mobile Source HAP Emissions ^c (tpy)
PXSS	04-013-9997	Phoenix, AZ	Residential	Urban/City Center	4,009,412	3,761,859 (2012)	29,515 (2010)	7,792.15	9,915.84
RFCO	08-045-0018	Carbondale, CO	Residential	Rural	57,302	74,036 (2012)	16,000 (2013)	3,787.70	327.61
RICO	08-045-0007	Rifle, CO	Commercial	Urban/City Center	57,302	74,036 (2012)	15,000 (2013)	3,787.70	327.61
RIVA	51-087-0014	East Highland Park, VA	Residential	Suburban	318,611	350,000 (2013)	72,000 (2012)	888.54	746.37
ROCH	36-055-1007	Rochester, NY	Residential	Urban/City Center	749,606	558,063 (2013)	85,162 (2012)	2,959.44	1,742.27
ROIL	17-119-9010	Roxana, IL	Industrial	Suburban	267,225	267,302 (2014)	7,750 (2013)	1,359.86	815.08
RUCA	06-065-8001	Rubidoux, CA	Residential	Suburban	2,292,507	1,788,322 (2013)	150,000 (2013)	3,826.19	3,244.32
RUVT	50-021-0002	Rutland, VT	Commercial	Urban/City Center	60,622	79,795 (2013)	10,400 (2013)	173.22	245.32
S4MO	29-510-0085	St. Louis, MO	Residential	Urban/City Center	1,319,860 ^f	1,117,375 (2013) ^f	100,179 (2013)	939.84	611.09
SDGA	13-089-0002	Decatur, GA	Residential	Suburban	713,340	479,533 (2013)	138,470 (2012)	1,358.69	1,814.77
SEWA	53-033-0080	Seattle, WA	Residential	Urban/City Center	2,044,449	1,791,383 (2013)	176,000 (2013)	7,310.24	6,890.17
SJCA	06-085-0005	San Jose, CA	Commercial	Urban/City Center	1,862,041	1,575,973 (2013)	115,000 (2012)	4,177.14	3,634.86
SKFL	12-103-0026	Pinellas Park, FL	Residential	Suburban	929,048	879,683 (2013)	47,500 (2013)	2,132.17	3,217.48

BOLD ITALICS = EPA-designated NATTS site

^aReference: Census Bureau, 2014

^bIndividual references provided in each state section.

^cReference: 2011 NEI version 2 (EPA, 2015a)

^dThe proportion of county-level population to the state-level population was applied to state-level vehicle registration figure and used as a surrogate when county-level vehicle registration counts were not available.

^eGPCO's hexavalent chromium monitor is at a separate, but adjacent, location; thus, this site has two AQS codes.

^fS4MO's county-level population and vehicle registration are the sum of the county- and city-level data.

Table 2-2. Site Characterizing Information for the 2013 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population ^a	County-level Vehicle Registration, # of Vehicles ^b (Year)	Estimated Daily Traffic, AADT ^b (Year)	County-level Stationary Source HAP Emissions ^c (tpy)	County-level Mobile Source HAP Emissions ^c (tpy)
SPAZ	04-013-4003	Phoenix, AZ	Residential	Urban/City Center	4,009,412	3,761,859 (2012)	25,952 (2011)	7,792.15	9,915.84
SPIL	17-031-3103	Schiller Park, IL	Mobile	Suburban	5,240,700	2,074,419 (2014)	186,100 (2012)	15,663.06	8,882.46
SSMS	27-087-0003	Columbus, MS	Residential	Urban/City Center	59,922	54,826 (2013)	19,000 (2013)	1,385.56	260.29
STMN	27-145-3053	St. Cloud, MN	Industrial	Suburban	152,092	221,636 (2013)	24,100 (2009)	1,217.04	1,275.96
<i>SYFL</i>	12-057-3002	Valrico, FL	Residential	Rural	1,291,578	1,157,057 (2013)	10,000 (2013)	3,155.70	4,260.15
TMOK	40-143-1127	Tulsa, OK	Residential	Urban/City Center	622,409	614,543 (2013)	12,500 (2012)	1,902.81	4,149.89
TOOK	40-143-0235	Tulsa, OK	Industrial	Urban/City Center	622,409	614,543 (2013)	64,424 (2012)	1,902.81	4,149.89
TROK	40-143-0179	Tulsa, OK	Industrial	Urban/City Center	622,409	614,543 (2013)	56,200 (2012)	1,902.81	4,149.89
TVKY	21-157-0014	Calvert City, KY	Industrial	Suburban	31,107	30,254 (2013)	2,230 (2011)	1,119.74	476.37
<i>UNVT</i>	50-007-0007	Underhill, VT	Forest	Rural	159,515	172,203 (2013)	1,100 (2011)	432.40	477.55
<i>WADC</i>	11-001-0043	Washington, D.C.	Commercial	Urban/City Center	646,449	322,350 (2012)	8,700 (2011)	933.45	829.76
<i>WPFL</i>	12-099-0008	Belle Glade, FL	Industrial	Rural	1,372,171	1,159,114 (2013)	6,600 (2013)	4,368.66	5,197.67

BOLD ITALICS = EPA-designated NATTS site

^aReference: Census Bureau, 2014

^bIndividual references provided in each state section.

^cReference: 2011 NEI version 2 (EPA, 2015a)

^dThe proportion of county-level population to the state-level population was applied to state-level vehicle registration figure and used as a surrogate when county-level vehicle registration counts were not available.

^eGPCO's hexavalent chromium monitor is at a separate, but adjacent, location; thus, this site has two AQS codes.

^fS4MO's county-level population and vehicle registration are the sum of the county- and city-level data.

Table 2-2. Site Characterizing Information for the 2013 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population^a	County-level Vehicle Registration, # of Vehicles^b (Year)	Estimated Daily Traffic, AADT^b (Year)	County-level Stationary Source HAP Emissions^c (tpy)	County-level Mobile Source HAP Emissions^c (tpy)
WPIN	18-097-0078	Indianapolis, IN	Residential	Suburban	928,281	830,851 (2013)	143,970 (2011)	2,627.90	4,042.65
YUOK	40-017-0101	Yukon, OK	Commercial	Suburban	126,123	106,000 (2013)	45,400 (2012)	680.10	447.57

BOLD ITALICS = EPA-designated NATTS site

^aReference: Census Bureau, 2014

^bIndividual references provided in each state section.

^cReference: 2011 NEI version 2 (EPA, 2015a)

^dThe proportion of county-level population to the state-level population was applied to state-level vehicle registration figure and used as a surrogate when county-level vehicle registration counts were not available.

^eGPCO's hexavalent chromium monitor is at a separate, but adjacent, location; thus, this site has two AQS codes.

^fS4MO's county-level population and vehicle registration are the sum of the county- and city-level data.

The proximity of the monitoring sites to different emissions sources, especially industrial facilities and heavily traveled roadways, often explains the observed spatial variations in ambient air quality. To provide a first approximation of the potential contributions of stationary and mobile source emissions on ambient air quality at each site, Table 2-2 also lists the following:

- The number of people living within each monitoring site's respective county.
- The county-level number of motor vehicles registered in each site's respective county, based on total vehicle registrations.
- The number of vehicles passing the nearest available representative roadway to the monitoring site, generally expressed as annual average daily traffic (AADT).
- Stationary and mobile source hazardous air pollutant (HAP) emissions for the monitoring site's residing county, according to version 2 of the 2011 National Emissions Inventory (NEI).

This information is discussed in further detail in Section 4.3 and the individual state sections.

2.2 Analytical Methods and Pollutants Targeted for Monitoring

Air pollution typically contains hundreds of components, including, but not limited to, VOCs, metals, and particulate matter (PM). Because the sampling and analysis required to monitor for every component of air pollution has been prohibitively expensive, the NMP focuses on specific pollutants that are analyzed at the laboratory using methods based on modified versions of EPA's Compendium methods, as listed below:

- *Compendium Method TO-15* was used to measure ambient air concentrations of 59 VOCs.
- *EPA-approved SNMOC Method* was used to measure 80 ozone precursors. This method was often performed concurrently with Method TO-15.
- *Compendium Method TO-11A* was used to measure ambient air concentrations of 15 carbonyl compounds.
- *Compendium Method TO-13A* was used to measure ambient air concentrations of 22 PAHs. For one site (KMMS), a subset (15) of these analytes was measured in addition to four phenols.
- A combination of *Compendium Method IO-3.5* and *EPA Federal Equivalency Methods (FEM) EQL-0512-201 and EQL-0512-202* was used to measure ambient air concentrations of 11 metals.

- *ASTM Method D7614* was used to measure ambient air concentrations of hexavalent chromium.

The target pollutants and methods utilized varied from monitoring site to monitoring site. The sample collection equipment at each site was installed either as a stand-alone sampler or in a temperature-controlled enclosure (usually a trailer or a shed) with the sampling probe inlet exposed to the ambient air. With these common setups, most monitoring sites sampled ambient air at heights approximately 5 feet to 20 feet above local ground level.

The detection limits of the analytical methods must be considered carefully when interpreting the corresponding ambient air monitoring data. By definition, method detection limits (MDLs) represent the lowest concentrations at which laboratory equipment have been experimentally determined to reliably quantify concentrations of selected pollutants to a specific confidence level. If a pollutant's concentration in ambient air is below the method sensitivity (as gauged by the MDL), the analytical method might not differentiate the pollutant from other pollutants in the sample or from the random "noise" inherent in the analyses. While quantification below the MDL is possible, the measurement reliability is lower. Therefore, when pollutants are present at concentrations below their respective detection limits, multiple analyses of the same sample may lead to a wide range of measurement results, including highly variable concentrations or "non-detect" observations (i.e., the pollutant was not detected by the instrument). Data analysts should exercise caution when interpreting monitoring data with a high percentage of reported concentrations at levels near or below the corresponding detection limits.

MDLs are determined annually at the ERG laboratory using 40 CFR, Part 136 Appendix B procedures (EPA, 2014c) in accordance with the specifications presented in the NATTS Technical Assistance Document (TAD) (EPA, 2009b). This procedure involves analyzing at least seven replicate standards spiked onto the appropriate sampling media and extracted (per analytical method). Instrument-specific detection limits (replicate analysis of standards in solution) are not determined because sampling media background and preparation variability would not be considered.

MDLs for metals samples were calculated using the procedure described by “Appendix D: DQ FAC Single Laboratory Procedure v2.4” (FAC, 2007), with the exception of the arsenic MDL for Teflon® filters. The Federal Advisory Committee (FAC) MDL procedure involves using historical blank filter data to calculate MDLs for each pollutant. For arsenic, the procedure described in 40 CFR was used to calculate the MDL rather than the FAC procedure because this metal is not present at a high enough level in the background on the filters.

Tables 2-3 through 2-8 identify the specific target pollutants for each analytical method and their corresponding MDLs, as determined for 2013. For the VOC and SNMOC analyses, the experimentally-determined MDLs do not change within a given year unless the sample was diluted. The 2013 VOC and SNMOC MDLs are presented in Tables 2-3 and 2-4, respectively. For the rest of the analytical methods, the MDLs vary due to the actual volume pulled through the sample or if the sample was diluted. For these analyses, the range and average MDL is presented for each pollutant in Tables 2-5 through 2-8, based on valid samples. If the MDLs presented in Tables 2-5 through 2-8 include an MDL for a diluted sample, the MDL may appear elevated. Dilutions cause the MDL to increase by a factor of the dilution; MDLs affected by dilution are denoted in the tables. ERG’s published pollutant-specific MDLs are also presented in Appendix B.

The following discussion presents an overview of the sampling and analytical methods. For detailed descriptions of the methods, refer to EPA’s original documentation of the Compendium Methods (EPA, 1998; EPA, 1999a; EPA, 1999b; EPA, 1999c; EPA, 1999d; EPA 2012a; ASTM, 2012; ASTM, 2013).

2.2.1 VOC and SNMOC Concurrent Sampling and Analytical Methods

VOC and SNMOC sampling and analysis can be performed concurrently using a combined methodology based on EPA Compendium Method TO-15 (EPA, 1999a) and the procedure presented in EPA’s “Technical Assistance Document for Sampling and Analysis of Ozone Precursors” (EPA, 1998), respectively. When referring to SNMOC, this report may refer to this method as the “concurrent SNMOC method” or “concurrent SNMOC analysis” because both methods can be employed at the same time to analyze the same sample. Ambient air samples for VOC and/or SNMOC analysis were collected in passivated stainless steel canisters. The ERG laboratory distributed the prepared canisters (i.e., cleaned and evacuated) to the

monitoring sites before each scheduled sample collection event, and site operators connected the canisters to air sampling equipment prior to each sample day. Prior to field sampling, the passivated canisters had internal pressures much lower than atmospheric pressure. Using this pressure differential, ambient air flowed into the canisters automatically once an associated system solenoid valve was opened. A mass flow controller on the sampling device inlet ensured that ambient air entered the canister at an integrated constant rate across the collection period. At the end of the 24-hour sampling period, the solenoid valve automatically closed and stopped ambient air from flowing into the canister. Site operators recovered and returned the canisters, along with the Chain of Custody (COC) forms and all associated documentation, to the ERG laboratory for analysis.

By analyzing each sample with gas chromatography incorporating mass spectrometry (operating in the Selected Ion Monitoring (SIM) mode) and flame ionization detection (GC/MS-FID), laboratory staff determined ambient air concentrations of 59 VOCs and/or 80 SNMOCs, and calculated the total nonmethane organic compounds (TNMOC) concentration. TNMOC is the sum of all hydrocarbon concentrations within the sample. Because *m*-xylene and *p*-xylene elute from the GC column at the same time, both the VOC and SNMOC analytical methods report only the sum concentration for these two isomers, and not the separate concentration for each isomer. Raw data for both methods are presented in Appendices C and D.

Table 2-3 presents the MDLs for the laboratory analysis of VOC samples with Method TO-15 and Table 2-4 presents the MDLs for the analysis of SNMOC samples. The MDL for every VOC is less than or equal to 0.047 parts per billion by volume (ppbv). SNMOC detection limits are expressed in parts per billion Carbon (ppbC). All of the SNMOC MDLs are less than or equal to 0.56 ppbC.

Table 2-3. 2013 VOC Method Detection Limits

Pollutant	2013 MDL (ppbv)	Pollutant	2013 MDL (ppbv)
Acetonitrile	0.031	Dichloromethane	0.014
Acetylene	0.017	1,2-Dichloropropane	0.017
Acrolein	0.047	<i>cis</i> -1,3-Dichloropropene	0.014
Acrylonitrile	0.025	<i>trans</i> -1,3-Dichloropropene	0.016
<i>tert</i> -Amyl Methyl Ether	0.013	Dichlorotetrafluoroethane	0.011
Benzene	0.019	Ethyl Acrylate	0.015
Bromochloromethane	0.016	Ethyl <i>tert</i> -Butyl Ether	0.014
Bromodichloromethane	0.019	Ethylbenzene	0.017
Bromoform	0.021	Hexachloro-1,3-Butadiene	0.028
Bromomethane	0.011	Methyl Isobutyl Ketone	0.018
1,3-Butadiene	0.011	Methyl Methacrylate	0.013
Carbon Disulfide	0.011	Methyl <i>tert</i> -Butyl Ether	0.012
Carbon Tetrachloride	0.016	<i>n</i> -Octane	0.012
Chlorobenzene	0.018	Propylene	0.036
Chloroethane	0.011	Styrene	0.018
Chloroform	0.015	1,1,2,2-Tetrachloroethane	0.026
Chloromethane	0.013	Tetrachloroethylene	0.014
Chloroprene	0.012	Toluene	0.015
Dibromochloromethane	0.018	1,2,4-Trichlorobenzene	0.024
1,2-Dibromoethane	0.017	1,1,1-Trichloroethane	0.015
<i>m</i> -Dichlorobenzene	0.026	1,1,2-Trichloroethane	0.019
<i>o</i> -Dichlorobenzene	0.023	Trichloroethylene	0.016
<i>p</i> -Dichlorobenzene	0.023	Trichlorofluoromethane	0.012
Dichlorodifluoromethane	0.011	Trichlorotrifluoroethane	0.013
1,1-Dichloroethane	0.015	1,2,4-Trimethylbenzene	0.018
1,2-Dichloroethane	0.016	1,3,5-Trimethylbenzene	0.019
1,1-Dichloroethene	0.011	Vinyl Chloride	0.011
<i>cis</i> -1,2-Dichloroethylene	0.016	<i>m,p</i> -Xylene ¹	0.029
<i>trans</i> -1,2-Dichloroethylene	0.012	<i>o</i> -Xylene	0.016

¹ Because *m*-xylene and *p*-xylene elute from the GC column at the same time, the VOC analytical method reports the sum of *m*-xylene and *p*-xylene concentrations and not concentrations of the individual isomers.

Table 2-4. 2013 SNMOC Method Detection Limits

Pollutant	2013 MDL (ppbC) ¹	Pollutant	2013 MDL (ppbC) ¹	Pollutant	2013 MDL (ppbC) ¹
Acetylene	0.22	1-Heptene	0.19	1-Pentene	0.18
Benzene	0.27	<i>n</i> -Hexane	0.30	<i>cis</i> -2-Pentene	0.21
1,3-Butadiene	0.19	1-Hexene	0.44	<i>trans</i> -2-Pentene	0.16
<i>n</i> -Butane	0.09	<i>cis</i> -2-Hexene	0.19	<i>a</i> -Pinene	0.19
1-Butene	0.16	<i>trans</i> -2-Hexene	0.19	<i>b</i> -Pinene	0.19
<i>cis</i> -2-Butene	0.10	Isobutane	0.09	Propane	0.11
<i>trans</i> -2-Butene	0.10	Isobutylene	0.19	<i>n</i> -Propylbenzene	0.14
Cyclohexane	0.20	Isopentane	0.09	Propylene	0.12
Cyclopentane	0.07	Isoprene	0.25	Propyne	0.19
Cyclopentene	0.19	Isopropylbenzene	0.17	Styrene	0.56
<i>n</i> -Decane	0.19	2-Methyl-1-Butene	0.19	Toluene	0.20
1-Decene	0.19	3-Methyl-1-Butene	0.19	<i>n</i> -Tridecane	0.19
<i>m</i> -Diethylbenzene	0.24	2-Methyl-1-Pentene	0.19	1-Tridecene	0.19
<i>p</i> -Diethylbenzene	0.21	4-Methyl-1-Pentene	0.19	1,2,3-Trimethylbenzene	0.15
2,2-Dimethylbutane	0.10	2-Methyl-2-Butene	0.19	1,2,4-Trimethylbenzene	0.20
2,3-Dimethylbutane	0.13	Methylcyclohexane	0.25	1,3,5-Trimethylbenzene	0.12
2,3-Dimethylpentane	0.36	Methylcyclopentane	0.15	2,2,3-Trimethylpentane	0.19
2,4-Dimethylpentane	0.32	2-Methylheptane	0.22	2,2,4-Trimethylpentane	0.17
<i>n</i> -Dodecane	0.33	3-Methylheptane	0.17	2,3,4-Trimethylpentane	0.14
1-Dodecene	0.19	2-Methylhexane	0.20	<i>n</i> -Undecane	0.22
Ethane	0.18	3-Methylhexane	0.45	1-Undecene	0.19
2-Ethyl-1-butene	0.19	2-Methylpentane	0.12	<i>m</i> -Xylene/ <i>p</i> -Xylene ²	0.17
Ethylbenzene	0.14	3-Methylpentane	0.13	<i>o</i> -Xylene	0.10
Ethylene	0.09	<i>n</i> -Nonane	0.11	Sum of Knowns	NA
<i>m</i> -Ethyltoluene	0.11	1-Nonene	0.19	Sum of Unknowns	NA
<i>o</i> -Ethyltoluene	0.15	<i>n</i> -Octane	0.27	TNMOC	NA
<i>p</i> -Ethyltoluene	0.20	1-Octene	0.19		
<i>n</i> -Heptane	0.17	<i>n</i> -Pentane	0.06		

¹ Concentration in ppbC = concentration in ppbv X number of carbon atoms in the compound.

² Because *m*-xylene and *p*-xylene elute from the GC column at the same time, the SNMOC analytical method reports the sum concentration for these two isomers and not concentrations of the individual isomers.

NA = Not applicable

2.2.2 Carbonyl Compound Sampling and Analytical Method

Sampling and analysis for carbonyl compounds was performed using methodology based on EPA Compendium Method TO-11A (EPA, 1999b). Ambient air samples for carbonyl compound analysis were collected by passing ambient air through an ozone scrubber and then through cartridges containing silica gel coated with 2,4-dinitrophenylhydrazine (DNPH), a compound known to react selectively and reversibly with many aldehydes and ketones. Carbonyl compounds in ambient air are retained in the sampling cartridge, while other compounds pass through without reacting with the DNPH-coated matrix. The ERG laboratory distributed the DNPH cartridges to the monitoring sites prior to each scheduled sample collection event and site operators connected the cartridges to the air sampling equipment. After each 24-hour sampling period, site operators recovered the cartridges and returned them, along with the COC forms and all associated documentation, to the ERG laboratory for analysis.

To quantify concentrations of carbonyl compounds in the sampled ambient air, laboratory analysts extracted the exposed DNPH cartridges with acetonitrile. High-performance liquid chromatography (HPLC) analysis and ultraviolet (UV) detection of these solutions determined the relative amounts of individual carbonyl compounds present in the original air sample. Because the three tolualdehyde isomers elute from the HPLC column at the same time, the carbonyl compound analytical method reports only the sum concentration for these isomers, and not the separate concentrations for each isomer. Raw data for Method TO-11A are presented in Appendix E.

Table 2-5 lists the MDLs reported by the ERG laboratory for measuring concentrations of 15 carbonyl compounds. Although the sensitivity varies from pollutant-to-pollutant and from site-to-site due to different volumes pulled through the samples, the average detection limit for valid samples reported by the ERG laboratory for every carbonyl compound is less than or equal to 0.016 ppbv.

Table 2-5. 2013 Carbonyl Compound Method Detection Limits

Pollutant	Minimum MDL (ppbv)	Maximum MDL (ppbv)	Average MDL (ppbv)
Acetaldehyde	0.005	0.020	0.008
Acetone	0.010	0.042 ²	0.016
Benzaldehyde	0.002	0.008	0.003
2-Butanone	0.001	0.009 ²	0.002
Butyraldehyde	0.002	0.008	0.003
Crotonaldehyde	0.003	0.011	0.004
2,5-Dimethylbenzaldehyde	0.001	0.006	0.002
Formaldehyde	0.008	0.036 ²	0.013
Hexaldehyde	0.001	0.006	0.002
Isovaleraldehyde	0.001	0.006	0.002
Propionaldehyde	0.003	0.011	0.004
Tolualdehydes ¹	0.003	0.011	0.004
Valeraldehyde	0.002	0.008	0.003

¹ The three tolualdehyde isomers elute from the HPLC column at the same time; thus, the analytical method reports only the sum concentration for these three isomers and not the individual concentrations.

²Indicates that sample dilution was required to perform analysis.

2.2.3 PAH Sampling and Analytical Method

PAH sampling and analysis was performed using methodology based on EPA Compendium Method TO-13A (EPA, 1999c) and ASTM D6209 (ASTM, 2013). The ERG laboratory prepared sampling media and supplied them to the sites before each scheduled sample collection event. The clean sampling PUF/XAD-2[®] cartridge and glass fiber filter are installed in a high volume sampler by the site operators and allowed to sample for 24 hours. Sample collection modules and COC forms and all associated documentation were returned to the ERG laboratory after sample collection. Within 14 days of sampling, the filter and cartridge are extracted together using a toluene in hexane solution using the Dionex Accelerated Solvent Extractor (ASE) 350 or ASE 300. The sample extract is concentrated to a final volume of 1.0 milliliter (mL). A volume of 1 microliter (μL) is injected into the GC/MS operating in the SIM mode to analyze for 22 PAHs. Raw data for Method TO-13A are presented in Appendix F.

Table 2-6 lists the MDLs for the 22 PAH target pollutants. PAH detection limits are expressed in nanograms per cubic meter (ng/m³). Although the sensitivity varies from pollutant-to-pollutant and from site-to-site due to the different volumes pulled through the samples, the average detection limit for valid samples reported by the ERG laboratory range from 0.030 ng/m³ (chrysene) to 0.275 ng/m³ (naphthalene).

Table 2-6. 2013 PAH Method Detection Limits

Pollutant	Minimum MDL (ng/m³)	Maximum MDL (ng/m³)¹	Average MDL (ng/m³)
Acenaphthene	0.029	0.500	0.048
Acenaphthylene	0.029	0.513	0.049
Anthracene	0.021	0.363	0.035
Benzo(a)anthracene	0.058	1.01	0.097
Benzo(a)pyrene	0.039	0.675	0.065
Benzo(b)fluoranthene	0.030	0.531	0.051
Benzo(e)pyrene	0.039	0.679	0.065
Benzo(g,h,i)perylene	0.027	0.477	0.046
Benzo(k)fluoranthene	0.038	0.670	0.064
Chrysene	0.018	0.309	0.030
Coronene	0.037	0.654	0.063
Cyclopenta[cd]pyrene	0.029	0.504	0.048
Dibenz(a,h)anthracene	0.028	0.485	0.046
Fluoranthene	0.034	0.589	0.056
Fluorene	0.039	0.692	0.066
9-Fluorenone	0.041	0.714	0.068
Indeno(1,2,3-cd)pyrene	0.025	0.438	0.042
Naphthalene	0.157	2.75	0.275
Perylene	0.028	0.483	0.046
Phenanthrene	0.030	0.531	0.051
Pyrene	0.036	0.623	0.060
Retene	0.072	1.26	0.121

¹Indicates that sample dilution was required to perform analysis.

The PAH samples collected at the KMMS site were also performed using methodology based on EPA Compendium Method TO-13A and ASTM D6209, although the media used and extraction process were adjusted slightly in order to provide for the analysis of phenol and cresols at the request of the monitoring agency. To achieve this, cartridges sent to the site contained only XAD-2[®] and the filter and cartridge are extracted together using a dichloromethane solution rather than a toluene in hexane solution. Raw data for KMMS are also presented in Appendix F. Table 2-7 lists the MDLs for the 18 PAH target pollutants analyzed in this manner. The average detection limit for valid samples reported by the ERG laboratory range from 0.132 ng/m³ (phenanthrene) to 2.24 ng/m³ (phenol).

Table 2-7. 2013 PAH/Phenols Method Detection Limits

Pollutant	Minimum MDL (ng/m ³)	Maximum MDL (ng/m ³)	Average MDL (ng/m ³)
Acenaphthene	0.158	0.288	0.192
Anthracene	0.150	0.272	0.182
Benzo(a)anthracene	0.164	0.299	0.200
Benzo(a)pyrene	0.244	0.444	0.297
Benzo(b)fluoranthene	0.241	0.438	0.293
Benzo(g,h,i)perylene	0.200	0.365	0.244
Benzo(k)fluoranthene	0.142	0.259	0.173
Chrysene	0.208	0.378	0.253
<i>m,p</i> -Cresols ^{2,3}	1.30	2.38	1.59
<i>o</i> -Cresol ²	0.678	1.24	0.825
Dibenz(a,h)anthracene	0.254	0.462	0.309
Fluoranthene	0.140	0.255	0.170
Fluorene	0.136	0.248	0.165
Indeno(1,2,3-cd)pyrene	0.226	0.412	0.275
Naphthalene	0.140	0.255	0.170
Phenanthrene	0.108	0.197	0.132
Phenol ²	1.04	12.4 ¹	2.24
Pyrene	0.138	0.252	0.168

¹Indicates that sample dilution was required to perform analysis.

²Identifies the pollutants not listed in Table 2-6.

³ Because *m*-cresol and *p*-cresol elute from the GC column at the same time, the analytical method reports the sum of *m*-cresol and *p*-cresol concentrations and not concentrations of the individual isomers.

2.2.4 Metals Sampling and Analytical Method

Ambient air samples for metals analysis were collected by passing ambient air through either 47mm Teflon[®] filters or 8" x 10" quartz filters, depending on the separate and distinct sampling apparatus used to collect the sample; the 47mm Teflon[®] filter is used for low-volume samplers, whereas the 8" x 10" quartz filter is used for high-volume samplers. EPA provided the filters to the monitoring sites. Sites sampled for either particulate matter less than 10 microns (PM₁₀) or total suspended particulate (TSP). Particulates in ambient air were collected on the filters and, after a 24-hour sampling period, site operators recovered and returned the filters, along with the COC forms and all associated documentation, to the ERG laboratory for analysis.

Extraction and analysis for the determination of speciated metals in or on particulate matter was performed using a combination of EPA Compendium Method IO-3.5 and EPA FEM Methods EQL-0512-201 and EQL-0512-202 (EPA, 1999d; EPA, 2012a). Upon receipt at the laboratory, the whole filters (47mm Teflon[®]) or filter strips (8" x 10" quartz) were digested using

a dilute nitric acid, hydrochloric acid, and/or hydrofluoric acid (Teflon® only) solution. The digestate was then quantified using ICP-MS to determine the concentration of individual metals present in the original air sample. Raw data for speciated metals are presented in Appendix G.

Table 2-8 lists the MDLs for the analysis of metals samples. Due to the difference in sample volume/filter collection media, there are two sets of MDLs listed in Table 2-8, one for each filter type. Although the sensitivity varies from pollutant-to-pollutant and from site-to-site due to the different volumes pulled through the samples, the average MDL for valid samples ranges from 0.003 ng/m³ (beryllium) to 2.49 ng/m³ (chromium) for the quartz filters and from 0.010 ng/m³ (cadmium) to 17.1 ng/m³ (chromium) for the Teflon® filters.

Table 2-8. 2013 Metals Method Detection Limits

Pollutant	Minimum MDL (ng/m ³)	Maximum MDL (ng/m ³)	Average MDL (ng/m ³)	Pollutant	Minimum MDL (ng/m ³)	Maximum MDL (ng/m ³)	Average MDL (ng/m ³)
8" X 10" Quartz Filters				47mm Teflon® Filters			
Antimony	0.011	0.019	0.015	Antimony	0.040	0.060	0.050
Arsenic	0.053	0.089	0.071	Arsenic	0.180	0.240	0.201
Beryllium	0.002	0.004	0.003	Beryllium	0.010	0.020	0.020
Cadmium	0.008	0.013	0.010	Cadmium	0.010	0.020	0.010
Chromium	1.87	3.12	2.49	Chromium	15.2	20.3	17.1
Cobalt	0.012	0.020	0.016	Cobalt	0.020	0.030	0.020
Lead	0.092	0.154	0.123	Lead	0.090	0.120	0.101
Manganese	0.099	0.165	0.132	Manganese	0.120	0.160	0.140
Mercury	0.003	0.005	0.004	Mercury	0.020	0.030	0.021
Nickel	0.945	1.58	1.26	Nickel	0.220	0.300	0.251
Selenium	0.021	0.034	0.027	Selenium	0.270	0.360	0.302

2.2.5 Hexavalent Chromium Sampling and Analytical Method

Hexavalent chromium was measured using the method described in ASTM D7614 (ASTM, 2012). Ambient air samples of hexavalent chromium on TSP were collected by passing ambient air through sodium bicarbonate impregnated acid-washed cellulose filters. ERG prepared and distributed the filters secured in Teflon® cartridges or in petri dishes, per the specific sampler used at each site, to the monitoring sites prior to each scheduled sample collection event. Site operators connected the cartridges (or installed the filters) to the air sampling equipment. After a 24-hour sampling period, site operators recovered the cartridges (or filters) and returned them, along with the COC forms and all associated documentation, to the ERG laboratory for analysis. Upon receipt at the laboratory, the filters were extracted using a

sodium bicarbonate solution. Ion chromatography (IC) analysis and ultraviolet-visible (UV-Vis) detection of the extracts determined the amount of hexavalent chromium present in each sample. Raw data for the hexavalent chromium method are presented in Appendix H.

Although the sensitivity varies from site-to-site due to the different volumes pulled through the samples, Table 2-9 presents the range and average detection limit (0.0040 ng/m³) for valid samples reported by the ERG laboratory across the program.

Table 2-9. 2013 Hexavalent Chromium Method Detection Limit

Pollutant	Minimum MDL (ng/m³)	Maximum MDL (ng/m³)	Average MDL (ng/m³)
Hexavalent Chromium	0.0032	0.0067	0.0040

2.3 Sample Collection Schedules

Table 2-10 presents the first and last date upon which sample collection occurred for each monitoring site sampling under the NMP in 2013. The first sample date for each site is generally at the beginning of January and sampling continued through the end of December, although there were a few exceptions:

- The instrumentation at the Oklahoma City, Oklahoma site (ADOK) was relocated to a new location in Yukon, Oklahoma (YUOK). Monitoring at ADOK was discontinued at the end of June after which monitoring at YUOK began in July.
- After June 30, 2013, sampling for hexavalent chromium under the NATTS program was no longer required. As a result, several sites stopped sampling under the NMP at this time as hexavalent chromium was the only pollutant sampled. These sites include: the Decatur, Georgia site (SDGA), the Horicon, Wisconsin site (HOWI), the Deer Park, Texas site (CAMS 35) and the Karnack, Texas site (CAMS 85).
- The Milwaukee, Wisconsin (MIWI) monitoring site completed a 1-year hexavalent chromium monitoring effort under the NMP in March. Similarly, the St. Cloud, Minnesota (STMN) monitoring site completed a 1-year hexavalent chromium monitoring effort under the NMP in May.
- The Long Beach, California (LBHCA) monitoring site completed a 1-year monitoring effort for PAHs under the NMP in July.
- The Belle Glade, Florida monitoring site (WPFL) conducted a 1-year monitoring effort for PAHs beginning in March 2013. To facilitate data analysis, the final 3 months of data from 2014 are included in Table 2-10 as well as the Florida state section (Section 10).

Table 2-10. 2013 Sampling Schedules and Completeness Rates

Site	Monitoring Period ¹		Carbonyl Compounds			VOCs			Hexavalent Chromium ²			Metals			SNMOCs			PAHs		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
ADOK	1/4/13	6/27/13	30	30	100	30	30	100	--	--	--	29	30	97	--	--	--	--	--	--
ANAK	1/4/13	12/30/13	--	--	--	61	61	100	--	--	--	--	--	--	--	--	--	62	61	>102
ASKY	1/4/13	12/30/13	61	61	100	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--
ASKY-M	1/4/13	12/30/13	--	--	--	--	--	--	--	--	--	60	61	98	--	--	--	--	--	--
ATKY	1/4/13	12/30/13	--	--	--	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--
AZFL	1/4/13	12/30/13	59	61	97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BAKY	1/4/13	12/30/13	--	--	--	--	--	--	--	--	--	60	61	98	--	--	--	--	--	--
BLKY	1/4/13	12/30/13	--	--	--	59	61	97	--	--	--	--	--	--	--	--	--	--	--	--
BMCO	1/4/13	12/24/13	28	30	93 ³	--	--	--	--	--	--	--	--	--	55	61	90	--	--	--
BOMA	1/4/13	12/30/13	--	--	--	--	--	--	30	30	100	61	61	100	--	--	--	61	61	100
BRCO	1/4/13	12/30/13	26	30	87 ³	--	--	--	--	--	--	--	--	--	57	61	93	--	--	--
BTUT	1/4/13	12/30/13	55	61	90	53	61	87	30	30	100	59	61	97	53	61	87	56	61	92
BURVT ³	1/10/13	12/24/13	--	--	--	31	30	>100	--	--	--	--	--	--	--	--	--	--	--	--
BXNY	1/4/13	12/30/13	--	--	--	--	--	--	30	30	100	--	--	--	--	--	--	60	61	98

A = Number of valid samples collected.

B = Number of valid samples that should be collected in 2013 based on sample schedule and start/end date of sampling.

C = Completeness (%).

¹ Begins with 1st sample collected and ends with last sample collected; date range presented may not be representative of each method-specific date range.

² Hexavalent chromium sampling was discontinued as a required element under the NATTS program at the end of June 2013.

³ Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.

⁴ Sampling method was the adjusted TO-13 method for PAHs and phenols, and was performed for a 6-month period from March to October.

⁵ Sampling at WPFL was performed over a 1-year period from March 2013 to March 2014; thus, 3 months of data from 2014 are included in this table and selected parts of this report.

BOLD ITALICS = EPA-designated NATTS site.

Orange shading indicates that completeness is below the MQO of 85 percent.

Table 2-10. 2013 Sampling Schedules and Completeness Rates (Continued)

Site	Monitoring Period ¹		Carbonyl Compounds			VOCs			Hexavalent Chromium ²			Metals			SNMOCs			PAHs		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
CAMS 35	1/4/13	6/27/13	--	--	--	--	--	--	30	30	100	--	--	--	--	--	--	--	--	--
CAMS 85	1/4/13	6/27/13	--	--	--	--	--	--	30	30	100	--	--	--	--	--	--	--	--	--
CCKY	1/4/13	12/30/13	--	--	--	61	61	100	--	--	--	56	61	92	--	--	--	--	--	--
CELA	1/4/13	12/30/13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	58	61	95
CHNJ	1/4/13	12/30/13	61	61	100	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--
CHSC	1/4/13	12/30/13	--	--	--	--	--	--	27	30	90	--	--	--	--	--	--	58	61	95
CSNJ	1/4/13	12/30/13	59	61	97	57	61	93	--	--	--	--	--	--	--	--	--	--	--	--
DEMI	1/4/13	12/30/13	61	61	100	62	61	>100	30	30	100	--	--	--	--	--	--	60	61	98
ELNJ	1/4/13	12/30/13	61	61	100	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--
GLKY	1/4/13	12/30/13	61	61	100	61	61	100	30	30	100	59	61	97	--	--	--	58	61	95
GPCO	1/4/13	12/30/13	58	61	95	61	61	100	28	30	93	--	--	--	--	--	--	56	61	92
HOWI	1/4/13	6/27/13	--	--	--	--	--	--	30	30	100	--	--	--	--	--	--	--	--	--
INDEM	1/4/13	12/30/13	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KMMS	1/4/13	12/30/13	--	--	--	30	61	98	--	--	--	--	--	--	--	--	--	30	30	100 ⁴

A = Number of valid samples collected.

B = Number of valid samples that should be collected in 2013 based on sample schedule and start/end date of sampling.

C = Completeness (%).

¹ Begins with 1st sample collected and ends with last sample collected; date range presented may not be representative of each method-specific date range.

² Hexavalent chromium sampling was discontinued as a required element under the NATTS program at the end of June 2013.

³ Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.

⁴ Sampling method was the adjusted TO-13 method for PAHs and phenols, and was performed for a 6-month period from March to October.

⁵ Sampling at WPFL was performed over a 1-year period from March 2013 to March 2014; thus, 3 months of data from 2014 are included in this table and selected parts of this report.

BOLD ITALICS = EPA-designated NATTS site.

Orange shading indicates that completeness is below the MQO of 85 percent.

Table 2-10. 2013 Sampling Schedules and Completeness Rates (Continued)

Site	Monitoring Period ¹		Carbonyl Compounds			VOCs			Hexavalent Chromium ²			Metals			SNMOCs			PAHs		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
LAKY	1/4/13	12/30/13	--	--	--	60	61	98	--	--	--	--	--	--	--	--	--	--	--	--
LBHCA	1/4/13	7/27/13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	29	35	83
LEKY	1/4/13	12/30/13	61	61	100	45	61	74	--	--	--	53	61	87	--	--	--	--	--	--
MIWI	1/4/13	3/11/13	--	--	--	--	--	--	11	12	92	--	--	--	--	--	--	--	--	--
<i>NBIL</i>	1/4/13	12/30/13	62	61	>100	61	61	100	30	30	100	59	61	97	61	61	100	58	61	95
NBNJ	1/4/13	12/30/13	62	61	>100	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--
OCOK	1/4/13	12/30/13	61	61	100	61	61	100	--	--	--	61	61	100	--	--	--	--	--	--
ORFL	1/4/13	12/30/13	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PACO	1/10/13	12/24/13	26	30	87 ³	--	--	--	--	--	--	--	--	--	52	61	85	--	--	--
PAFL ³	1/10/13	12/24/13	--	--	--	--	--	--	--	--	--	30	30	100	--	--	--	--	--	--
<i>PRRI</i>	1/4/13	12/30/13	--	--	--	--	--	--	30	30	100	--	--	--	--	--	--	59	61	97
<i>PXSS</i>	1/4/13	12/30/13	60	61	98	61	61	100	29	30	97	61	61	100	--	--	--	58	61	95
RFCO ³	1/10/13	12/24/13	27	30	90	--	--	--	--	--	--	--	--	--	29	30	97	--	--	--
RICO	1/4/13	12/24/13	25	30	83 ³	--	--	--	--	--	--	--	--	--	57	61	93	--	--	--

A = Number of valid samples collected.

B = Number of valid samples that should be collected in 2013 based on sample schedule and start/end date of sampling.

C = Completeness (%).

¹ Begins with 1st sample collected and ends with last sample collected; date range presented may not be representative of each method-specific date range.

² Hexavalent chromium sampling was discontinued as a required element under the NATTS program at the end of June 2013.

³ Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.

⁴ Sampling method was the adjusted TO-13 method for PAHs and phenols, and was performed for a 6-month period from March to October.

⁵ Sampling at WPFL was performed over a 1-year period from March 2013 to March 2014; thus, 3 months of data from 2014 are included in this table and selected parts of this report.

BOLD ITALICS = EPA-designated NATTS site.

Orange shading indicates that completeness is below the MQO of 85 percent.

Table 2-10. 2013 Sampling Schedules and Completeness Rates (Continued)

Site	Monitoring Period ¹		Carbonyl Compounds			VOCs			Hexavalent Chromium ²			Metals			SNMOCs			PAHs		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
RIVA	1/4/13	12/30/13	--	--	--	--	--	--	60	61	98	--	--	--	--	--	--	58	61	95
ROCH	1/4/13	12/30/13	--	--	--	--	--	--	30	31	97	--	--	--	--	--	--	56	61	92
ROIL	1/4/13	12/30/13	61	61	100	60	61	98	--	--	--	--	--	--	--	--	--	--	--	--
RUCA	1/4/13	12/30/13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	58	61	95
RUVT ³	1/10/13	12/24/13	--	--	--	31	30	>100	--	--	--	--	--	--	--	--	--	--	--	--
S4MO	1/4/13	12/30/13	61	61	100	61	61	100	59	61	97	61	61	100	--	--	--	60	61	98
SDGA	1/4/13	7/15/13	--	--	--	--	--	--	30	33	91	--	--	--	--	--	--	--	--	--
SEWA	1/4/13	12/30/13	57	61	93	57	61	93	29	30	97	60	61	98	--	--	--	57	61	93
SJJCA	1/4/13	12/30/13	--	--	--	--	--	--	--	--	--	60	61	98	--	--	--	59	61	97
SKFL	1/4/13	12/30/13	60	61	98	--	--	--	30	30	100	--	--	--	--	--	--	59	61	97
SPAZ ³	1/4/13	12/30/13	--	--	--	31	31	100	--	--	--	--	--	--	--	--	--	--	--	--
SPIL	1/4/13	12/30/13	61	61	100	60	61	98	--	--	--	--	--	--	--	--	--	--	--	--
SSMS	1/4/13	12/30/13	--	--	--	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--
STMN	1/4/13	5/28/13	--	--	--	--	--	--	24	25	96	--	--	--	--	--	--	--	--	--

A = Number of valid samples collected.

B = Number of valid samples that should be collected in 2013 based on sample schedule and start/end date of sampling.

C = Completeness (%).

¹ Begins with 1st sample collected and ends with last sample collected; date range presented may not be representative of each method-specific date range.

² Hexavalent chromium sampling was discontinued as a required element under the NATTS program at the end of June 2013.

³ Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.

⁴ Sampling method was the adjusted TO-13 method for PAHs and phenols, and was performed for a 6-month period from March to October.

⁵ Sampling at WPFL was performed over a 1-year period from March 2013 to March 2014; thus, 3 months of data from 2014 are included in this table and selected parts of this report.

BOLD ITALICS = EPA-designated NATTS site.

Orange shading indicates that completeness is below the MQO of 85 percent.

Table 2-10. 2013 Sampling Schedules and Completeness Rates (Continued)

Site	Monitoring Period ¹		Carbonyl Compounds			VOCs			Hexavalent Chromium ²			Metals			SNMOCs			PAHs		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
<i>SYFL</i>	1/4/13	12/30/13	61	61	100	--	--	--	29	30	97	--	--	--	--	--	--	29	30	97
TOOK	1/4/13	12/30/13	61	61	100	61	61	100	--	--	--	58	61	95	--	--	--	--	--	--
TROK	1/4/13	12/30/13	61	61	100	61	61	100	--	--	--	56	61	92	--	--	--	--	--	--
TVKY	1/4/13	12/30/12	--	--	--	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--
<i>UNVT</i>	1/4/13	12/30/13	--	--	--	60	61	98	28	30	93	60	61	98	--	--	--	59	61	97
<i>WADC</i>	1/4/13	12/30/13	--	--	--	--	--	--	30	30	100	--	--	--	--	--	--	60	61	98
WPFL ^{3,5}	3/11/13	3/30/14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	30	33	91
WPIN	1/4/13	12/30/13	58	61	95	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
YUOK	7/3/13	12/30/13	30	31	97	30	31	97	--	--	--	31	31	100	--	--	--	--	--	--

A = Number of valid samples collected.

B = Number of valid samples that should be collected in 2013 based on sample schedule and start/end date of sampling.

C = Completeness (%).

¹ Begins with 1st sample collected and ends with last sample collected; date range presented may not be representative of each method-specific date range.

² Hexavalent chromium sampling was discontinued as a required element under the NATTS program at the end of June 2013.

³ Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.

⁴ Sampling method was the adjusted TO-13 method for PAHs and phenols, and was performed for a 6-month period from March to October.

⁵ Sampling at WPFL was performed over a 1-year period from March 2013 to March 2014; thus, 3 months of data from 2014 are included in this table and selected parts of this report.

BOLD ITALICS = EPA-designated NATTS site.

Orange shading indicates that completeness is below the MQO of 85 percent.

According to the NMP schedule, 24-hour integrated samples were collected at each monitoring site on a 1-in-6 day schedule and each sample collection began and ended at midnight, local standard time. However, there were some exceptions, as some sites collected samples on a 1-in-12 day schedule, dependent upon location and monitoring objectives:

- SNMOC samples were collected on a 1-in-6 day schedule while carbonyl compounds were collected on a 1-in-12 day schedule at BMCO, BRCO, PACO, and RICO. Sampling at RFCO was conducted on a 1-in-12 day schedule for both methods.
- The South Phoenix, Arizona site (SPAZ) collected VOC samples on a 1-in-12 day schedule.
- The Orlando, Florida site (PAFL) collected metals samples on a 1-in-12 day schedule.
- The Belle Glade, Florida site (WPFL) collected PAH samples on a 1-in-12 day schedule.
- The Burlington and Rutland, Vermont sites (BURVT and RUVT) collected VOC samples on a 1-in-12 day schedule.

Table 2-10 shows the following:

- 34 sites collected VOC samples.
- 33 sites collected carbonyl compound samples.
- 7 sites collected SNMOC samples.
- 24 sites collected PAH samples (with one additional site collecting PAHs/phenols).
- 20 sites collected metals samples.
- 24 sites collected hexavalent chromium samples.

As part of the sampling schedule, site operators were instructed to collect duplicate (or collocated) samples on roughly 10 percent of the sample days for select methods when duplicate (or collocated) samplers were available. Field blanks were collected once a month for carbonyl compounds, hexavalent chromium, metals, and PAHs. Sampling calendars were distributed to help site operators schedule the collection of samples, duplicates, and field blanks. In cases where a valid sample was not collected on a given scheduled sample day, site operators were instructed to reschedule or “make up” samples on other days. This practice explains why some monitoring locations periodically strayed from the 1-in-6 or 1-in-12 day sampling schedule.

The 1-in-6 or 1-in-12 day sampling schedule provides cost-effective approaches to data collection for trends characterization of toxic pollutants in ambient air and ensures that sample days are evenly distributed among the seven days of the week to allow weekday/weekend comparison of air quality. Because the 1-in-6 day schedule yields twice the number of measurements than the 1-in-12 day schedule, data characterization based on this schedule tends to be more representative.

2.4 Completeness

Completeness refers to the number of valid samples collected and analyzed compared to the number of total samples expected based on a 1-in-6 or 1-in-12 day sample schedule. Monitoring programs that consistently generate valid samples have higher completeness than programs that consistently have invalid samples. The completeness of an air monitoring program, therefore, can be a qualitative measure of the reliability of air sampling and laboratory analytical equipment as well as a measure of the efficiency with which the program is managed. The completeness for each monitoring site and method sampled is presented in Table 2-10.

The measurement quality objective (MQO) for completeness based on the EPA-approved Quality Assurance Project Plan (QAPP) specifies that at least 85 percent of samples from a given monitoring site must be collected and analyzed successfully to be considered sufficient for data trends analysis (ERG, 2013). The data in Table 2-10 show that three datasets from a total of 143 datasets from the 2013 NMP monitoring effort did not meet this MQO (orange shaded cells in Table 2-10):

- Sampler issues at RICO resulted in a carbonyl compound completeness less than 85 percent.
- Sampler issues during the spring of 2013 combined with a shortened sampling duration (monitoring was discontinued in July 2013) resulted in a PAH completeness less than 85 percent for LBHCA.
- A leak in the sample line was discovered at LEKY and resulted in the invalidation of VOC samples collected between February 9, 2013 and May 4, 2013.

Appendix I identifies samples that were invalidated and lists the reason for invalidation, based on the applied AQS null code.

Table 2-11 presents method-specific completeness. Method-specific completeness was greater than 90 percent for all methods performed under the 2013 NMP and ranged from 91.9 percent for SNMOCs to 100 percent for PAH/Phenols.

Table 2-11. Method Completeness Rates for 2013

Method	# of Valid Samples	# of Samples Scheduled	Method Completeness (%)	Minimum Site-Specific Completeness (%)	Maximum Site-Specific Completeness (%)
VOCs	1,883	1,921	98.0	74 (LEKY)	>100 (3 sites)
SNMOCs	364	396	91.9	85 (PACO)	100 (NBIL)
Carbonyl Compounds	1,758	1,797	97.8	83 (RICO)	>100 (2 sites)
PAHs ¹	1,310	1,371	95.6	83 (LBHCA)	>100 (ANAK)
PAHs/Phenols	30	30	100	100 (KMMS)	
Metals Analysis	1,090	1,128	96.6	87 (LEKY)	100 (6 sites)
Hexavalent Chromium	744	763	97.5	90 (CHSC)	100 (12 sites)

BOLD ITALICS = EPA-designated NATTS site.

¹Excludes the eight samples collected at WPFL in 2014.

3.0 Summary of the 2013 National Monitoring Programs Data Treatment and Methods

This section summarizes the data treatment and approaches used to evaluate the measurements generated from samples collected during the 2013 NMP sampling year. These data were analyzed on a program-wide basis as well as a site-specific basis.

Results from the program-wide data analyses are presented in Section 4 while results from the site-specific data analyses are presented in the individual state sections, Sections 5 through 30.

A total of 262,831 valid air toxics concentrations (including non-detects, duplicate analyses, replicate analyses, and analyses for collocated samples) were produced from 9,418 valid samples collected at 66 monitoring sites during the 2013 reporting year. A tabular presentation of the raw data and statistical summaries are found in Appendices C through O, as presented in Table 3-1. Appendix P serves as the glossary for the NMP report and many of the terms discussed and defined throughout the report are provided there.

Table 3-1. Overview and Layout of Data Presented

Pollutant Group	Number of Sites	Appendix	
		Raw Data	Statistical Summary
VOCs	34	C	J
SNMOCs	7	D	K
Carbonyl Compounds	33	E	L
PAHs or PAHs/Phenols	24/1	F	M
Metals	20	G	N
Hexavalent Chromium	24	H	O

3.1 Approach to Data Treatment

This section examines the various statistical tools employed to characterize the data collected during the 2013 sampling year. Certain data analyses were performed at the program-level, other data analyses were performed at both the program-level and on a site-specific basis, and still other approaches were reserved for site-specific data analyses only. Regardless of the data analysis employed, it is important to understand how the concentration data were treated. The following paragraphs describe techniques used to prepare this large quantity of concentration data for data analysis.

For each monitoring site, the primary, duplicate (or collocated), and replicate measurements were averaged together for each pollutant in order to calculate a single concentration per sample date and method. This is referred to as the *preprocessed daily measurement*.

Concentrations of *m,p*-xylene and *o*-xylene were summed together and are referred to as “total xylenes,” or simply “xylenes” throughout the remainder of this report, with a few exceptions. One exception is Section 4.1, which examines the results of basic statistical calculations performed on the dataset. Table 4-1 and Table 4-2, which are the method-specific statistics for VOCs and SNMOCs, respectively, present the xylenes results retained as *m,p*-xylene and *o*-xylene species. Data for the isomers are also presented individually in the Data Quality section (Section 31). Similarly, concentrations of *m,p*-cresol and *o*-cresol were also summed together and are referred to as “cresols” throughout most of this report, with the same exceptions as xylenes.

For the 2013 NMP, where statistical parameters are calculated based on the preprocessed daily measurements, zeros have been substituted for non-detect results. This approach is consistent with how data are loaded into AQS per the NATTS TAD (EPA, 2009b) as well as other EPA air toxics monitoring programs, such as the School Air Toxics Monitoring Program (SATMP) (EPA, 2011a), and other associated reports, such as the NATTS Network Assessment (EPA, 2012b). The substitution of zeros for non-detects results in lower average concentrations of pollutants that are rarely measured at or above the associated MDL and/or have a relatively high MDL.

In order to compare concentrations across multiple sampling methods, all concentrations have been converted to a common unit of measure: microgram per cubic meter ($\mu\text{g}/\text{m}^3$). However, whenever a particular sampling method is isolated from others, such as in Tables 4-1 through 4-6, the statistical parameters are presented in the unit of measure associated with the particular sampling method. Thus, it is important to pay close attention to the unit of measure associated with each data analysis discussed in this and subsequent sections of the report.

In addition, this report presents various time-based averages to summarize the measurements for a specific site; where applicable, quarterly and annual averages were calculated for each site. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly averages include the substitution of zeros for all non-detects. Quarterly averages for the first quarter in the calendar year include measurements from January, February, and March; the second quarter includes April, May, and June; the third quarter includes July, August, and September; and the fourth quarter includes October, November, and December. A minimum of 75 percent of the total number of samples possible within a given quarter must be valid to have a quarterly average presented. For sites sampling on a 1-in-6 day sampling schedule, 12 samples represents 75 percent; for sites sampling on a 1-in-12 day schedule, six samples represents 75 percent. Sites that do not meet these minimum requirements do not have a quarterly average concentration presented. Sites may not meet this minimum requirement due to invalidated or missed samples or because of a shortened sampling duration.

An *annual average* includes all measured detections and substituted zeros for non-detects for a given calendar year (2013). Annual average concentrations were calculated for monitoring sites where three quarterly averages could be calculated and where method completeness, as presented in Section 2.4, is greater than or equal to 85 percent. Sites that do not meet these requirements do not have an annual average concentration presented.

The concentration averages presented in this report are often provided with their associated 95 percent confidence intervals. Confidence intervals represent the interval within which the true average concentration falls 95 percent of the time. The confidence interval includes an equal amount of quantities above and below the concentration average. For example, an average concentration may be written as $1.25 \pm 0.25 \mu\text{g}/\text{m}^3$; thus, the interval over which the true average would be expected to fall would be between 1.00 to $1.50 \mu\text{g}/\text{m}^3$ (EPA, 2011a).

3.2 Human Health Risk and the Pollutants of Interest

A practical approach to making an assessment on a large number of measurements is to focus on a subset of pollutants based on the end-use of the dataset. Thus, a subset of pollutants is selected for further data analyses for each annual NMP report. Health risk-based calculations have been used to identify “pollutants of interest” in recent years. For the 2013 NMP report, the

pollutants of interest are also based on risk potential. The following paragraphs provide an overview of health risk terms and concepts and outline how the pollutants of interest are determined and then used throughout the remainder of the report.

EPA defines risk as “the probability that damage to life, health, or the environment will occur as a result of a given hazard (such as exposure to a toxic chemical)” (EPA, 2011b). Human health risk can be further defined in terms of time. Chronic effects develop from repeated exposure over long periods of time; acute effects develop from a single exposure or from exposures over short periods of time (EPA, 2010a). Health risk is also route-specific; that is, risk varies depending upon route of exposure (i.e., oral vs. inhalation). Because this report covers air toxics in ambient air, only the inhalation route is considered. Hazardous air pollutants (HAPs) are those pollutants “known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects” (EPA, 2014d).

Health risks are typically divided into cancer and noncancer effects when referring to human health risk. Cancer risk is defined as the likelihood of developing cancer as a result of exposure to a given concentration over a 70-year period, and is presented as the number of people at risk for developing cancer per million people. Noncancer health effects include conditions such as asthma; noncancer health risks are presented as a hazard quotient, the value below which no adverse health effects are expected (EPA, 2011b). Cancer risk is presented as a probability while the hazard quotient is a ratio and thus, a unitless value.

In order to assess health risk, EPA and other agencies develop toxicity factors, such as cancer unit risk estimates (UREs) and noncancer reference concentrations (RfCs), to estimate cancer and noncancer risks and to identify (or screen) where air toxics concentrations may present a human health risk. EPA has published a guidance document outlining a risk-based screening approach for performing an initial screen of ambient air toxics monitoring datasets (EPA, 2010a). The *preliminary risk-based screening process* provided in this report is an adaption of that approach and is a risk-based methodology for analysts and interested parties to identify which pollutants may pose a health risk in their area. Cancer UREs and noncancer RfCs are converted into screening values. The cancer screening value is the cancer URE converted to $\mu\text{g}/\text{m}^3$ and divided by one million. The noncancer screening value is one-tenth of the noncancer RfC and converted from mg/m^3 to $\mu\text{g}/\text{m}^3$. The final screening value used in this report is the

lower of the two screening values. Not all pollutants analyzed under the NMP have screening values; of the pollutants sampled under the NMP, 71 pollutants have screening values. The screening values used in this analysis are presented in Appendix Q¹.

The preprocessed daily measurements of the target pollutants were compared to these chronic risk screening values in order to identify pollutants of interest across the program. The following risk-based screening process was used to identify pollutants of interest:

1. The TO-15 and SNMOC methods have 12 pollutants in common. If a pollutant was measured by both the TO-15 and SNMOC methods at the same site, the TO-15 results were used. The purpose of this data treatment is to have one concentration per pollutant for each sample day.
2. Each preprocessed daily measurement was compared to its associated risk screening value. Concentrations that are greater than the risk screening value are described as “failing the screen.”
3. The number of failed screens was summed for each applicable pollutant.
4. The percent contribution of the number of failed screens to the total number of failed screens program-wide was calculated for each applicable pollutant.
5. The pollutants contributing to the top 95 percent of the total failed screens were identified as pollutants of interest.

In regards to Step 5 above, the actual cumulative contribution may exceed 95 percent in order to include all pollutants contributing to the minimum 95 percent criteria (refer to nickel in Table 4-7 for an example). In addition, if the 95 percent cumulative criterion is reached, but the next pollutant contributed equally to the number of failed screens, that pollutant was also designated as a pollutant of interest. Results of the program-wide risk-based screening process are provided in Section 4.2.

Laboratory analysts have indicated that acetonitrile concentrations may be artificially high (or non-existent) due to site conditions and potential cross-contamination with concurrent sampling of carbonyl compounds using Method TO-11A. The inclusion of acetonitrile in data analyses must be determined on a site-specific basis by the agency responsible for the site. Thus,

¹ The risk-based screening process used in this report comes from guidance from EPA Region 4’s report “A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Datasets” but the screening values referenced in that report have since been updated (EPA, 2014e).

acetonitrile results are excluded from certain program-wide and site-specific data analyses, particularly those related to risk.

Laboratory analysts have indicated that acrylonitrile and carbon disulfide concentrations may also be artificially high due to potential contamination of the samplers using Method TO-15. The inclusion of acrylonitrile and carbon disulfide in data analyses must be determined on a site-specific basis by the agency responsible for the site. Thus, results for these pollutants are also excluded from program-wide and site-specific data analyses related to risk.

Acrolein was also excluded from the preliminary risk-based screening process due to questions about the consistency and reliability of the measurements (EPA, 2010b). Thus, the results from sampling and analysis of this pollutant have been excluded from any risk-related analyses presented in this report, similar to acetonitrile, acrylonitrile, and carbon disulfide.

The NATTS TAD (EPA, 2009b) identifies 19 pollutants (“MQO Core Analytes”) that participating sites are required to sample and analyze for under the NATTS program. Table 3-2 presents these 19 NATTS MQO Core Analytes. Monitoring for these pollutants is required because they are major health risk drivers according to EPA (EPA, 2009b). Many of the pollutants listed in Table 3-2 are identified as pollutants of interest via the risk-based screening process. Note that beginning in July 2013, hexavalent chromium was removed from the list of required pollutants for which to sample under the NATTS program.

The “pollutants of interest” designation is reserved for pollutants targeted for sampling through the NMP that meet the identified criteria. As discussed in Section 2.0, agencies operating monitoring sites that participate under the NMP are not required to have their samples analyzed by ERG or may measure pollutants other than those targeted under the NMP. In these cases, data are generated by sources other than ERG and are not included in the preliminary risk-based screening process or any other data analysis contained in this report.

Table 3-2. NATTS MQO Core Analytes

Pollutant	Class/Method
Acrolein	VOCs/TO-15
Benzene	
1,3-Butadiene	
Carbon Tetrachloride	
Chloroform	
Tetrachloroethylene	
Trichloroethylene	
Vinyl Chloride	
Acetaldehyde	Carbonyl Compounds/ TO-11A
Formaldehyde	
Naphthalene	PAHs or PAHs/Phenols/ TO-13A
Benzo(a)pyrene	
Arsenic	Metals/ IO-3.5 and EQL-0512- 201/202
Beryllium	
Cadmium	
Manganese	
Lead	
Nickel	
Hexavalent chromium	Metals/ASTM D7614

3.3 Additional Program-Level Analyses of the 2013 National Monitoring Programs Dataset

This section summarizes additional analyses performed on the 2013 NMP dataset at the program level. Additional program-level analyses include an examination of the potential contribution from motor vehicles and a review of how concentrations vary among the sites themselves and from quarter-to-quarter. The results of these analyses are presented in Sections 4.3 through 4.5.

3.3.1 The Contribution from Mobile Source Emissions on Spatial Variations

Mobile source emissions contribute significantly to air pollution. “Mobile sources” are emitters of air pollutants that are capable of moving from place to place; mobile sources include both onroad (i.e., passenger vehicles) and nonroad emissions (i.e., lawnmowers). Pollutants found in motor vehicle exhaust generally result from incomplete combustion of vehicle fuels. Although modern vehicles and, more recently, vehicle fuels have been engineered to minimize air emissions, all motor vehicles with internal combustion engines emit a wide range of pollutants. The magnitude of these emissions primarily depends on the volume of traffic, while

the chemical profile of these emissions depends more on vehicle design and fuel formulation. This report uses a variety of parameters to quantify and relate motor vehicle emissions to ambient air quality, which are discussed further in Section 4.3:

- Emissions data from the latest version of the NEI
- Total hydrocarbon concentrations
- Motor vehicle ownership data
- Estimated daily traffic volume
- Vehicle miles traveled (VMT).

This report uses Pearson correlation coefficients to measure the degree of correlation between two variables, such as the ones listed above. By definition, Pearson correlation coefficients always lie between -1 and +1. Three qualification statements apply:

- A correlation coefficient of -1 indicates a perfectly “negative” relationship, indicating that increases in the magnitude of one variable are associated with proportionate decreases in the magnitude of the other variable, and vice versa.
- A correlation coefficient of +1 indicates a perfectly “positive” relationship, indicating that the magnitudes of two variables both increase and both decrease proportionately.
- Data that are completely uncorrelated have Pearson correlation coefficients of 0.

Therefore, the sign (positive or negative) and magnitude of the Pearson correlation coefficient indicate the direction and strength, respectively, of data correlations. In this report, correlation coefficients greater than or equal to 0.50 and less than or equal to -0.50 are classified as strong, while correlation coefficients less than 0.50 and greater than -0.50 are classified as weak.

The number of observations used in a calculation is an important factor to consider when analyzing the correlations. A correlation using relatively few observations may skew the correlation, making the degree of correlation appear higher (or lower) than it may actually be. Thus, in this report, a minimum of five data points must be available to present a correlation.

3.3.2 Variability Analyses

Variability refers to the degree of difference among values in a dataset. Two types of variability are analyzed for this report and are discussed in Section 4.4. The first type of variability assessed in this report is inter-site variability. For this analysis, the annual average concentration for each site is plotted in the form of a bar graph for each program-wide pollutant of interest. The criteria for calculating an annual average are discussed in Section 3.1 and sites that do not meet these requirements do not have an annual average concentration presented. This assessment allows the reader to visualize how concentrations varied across the sites for a particular pollutant of interest. In order to further this analysis, the program-level average concentrations, as presented in Tables 4-1 through 4-6 in Section 4.1, are plotted against the site-specific annual averages. This allows the reader to see how the site-specific annual averages compare to the program-level average for each pollutant. Note that the average concentrations shown for VOCs, SNMOCs, and carbonyl compounds in Tables 4-1 through 4-3 are presented in method-specific units, but have been converted to a common unit of measurement ($\mu\text{g}/\text{m}^3$) for the purposes of this analysis.

Quarterly variability is the second type of variability assessed in this report. The concentration data for each site were divided into the four quarters of the year, as described in Section 3.1. The completeness criteria, also described in Section 3.1, are maintained here as well. The site-specific quarterly averages are illustrated by bar graphs for each program-level pollutant of interest. This analysis allows for a determination of a quarterly (or seasonal) correlation with the magnitude of concentrations for a specific pollutant.

3.3.3 Greenhouse Gas Assessment

There is considerable discussion about climate change among atmospheric and environmental scientists. Climate change refers to an extended period of change in meteorological variables used to determine climate, such as temperature and precipitation. Researchers are typically concerned with greenhouse gases (GHGs), which are those that cause heat to be retained in the atmosphere (EPA, 2015b).

Agencies researching the effects of greenhouse gases tend to concentrate primarily on tropospheric levels of these gases. The troposphere is the lowest level of the atmosphere, whose height varies depending on season and latitude. This is also the layer in which weather

phenomenon occur (NOAA, 2015a). A few VOCs measured with Method TO-15 are greenhouse gases, although these measurements reflect the concentration at the surface, or in the breathing zone, and do not represent the entire troposphere. Section 4.5 presents the 10 GHGs currently measured with Method TO-15, their 100-year Global Warming Potential (GWP), and the average concentration across the NMP program. GWP is a way to determine a pollutant's ability to retain heat relative to carbon dioxide, which is the predominant anthropogenic GHG in the atmosphere; higher GWPs indicate a higher potential contribution to global warming (EPA, 2015c). In the future, additional GHGs may be added to the NMP Method TO-15 target pollutant list in order to assess their surface-level ambient concentrations.

3.4 Additional Site-Specific Analyses

In addition to the analyses described in the preceding sections, the state-specific sections contain additional analyses that are applicable only at the local level. This section provides an overview of these analyses but does not discuss their results. Results of these site-specific analyses are presented in the individual state-specific sections (Sections 5 through 30).

3.4.1 Site Characterization

For each site participating in the 2013 NMP, a site characterization was performed. This characterization includes a review of the nearby area surrounding the monitoring site; plotting of emissions sources surrounding the monitoring site; and obtaining population, vehicle registration, traffic data, and other characterizing information. For the 2013 NMP report, the locations of point sources located near the monitoring sites were obtained from Version 2 of the 2011 NEI (EPA, 2015a). Sources for other site-characterizing data are provided in the individual state sections.

3.4.2 Meteorological Analysis

Several site-specific meteorological analyses were performed in order to help readers determine which meteorological factors may play a role in a given site's air quality. First, an overview of the general climatology is provided, based on the area where each site is located, to give readers a general idea of what types of meteorological conditions likely affect the site. Next, the average (or mean) for several meteorological parameters (such as temperature and relative humidity) are provided. Two averages are presented for each parameter, one average for all days in 2013 and one average for sample days only. These two averages provide an indication of how

meteorological conditions on sample days varied from typical conditions experienced throughout the year. These averages are based on hourly meteorological observations collected from the National Weather Service (NWS) weather station nearest each site and obtained from the National Climatic Data Center (NCDC) (NCDC, 2013 and 2014). Although some monitoring sites have meteorological instruments on-site and report these data to AQS, NWS data were chosen for this analysis for several reasons:

- Some sites do not have meteorological instruments on-site.
- Some sites collect meteorological data but do not report them to AQS; thus, they are not readily available.
- There are differences among the sites in the meteorological parameters reported to AQS.

Although there are limitations to using NWS data, the data used are standardized and quality-assured per NWS protocol.

In order to further characterize the meteorology at or near each monitoring site, wind roses were constructed for each site. A wind rose shows the frequency at which a given wind speed and direction are measured near the monitoring site, capturing day-to-day fluctuations at the surface while allowing the predominant direction from which the wind blows to be identified. Thus, a wind rose is often used in determining where to install an ambient monitoring site when trying to capture emissions from an upwind source. A wind rose may also be useful in determining whether high concentrations correlate with a specific wind direction. A wind rose shows the frequency of wind directions as petals positioned around a 16-point compass, and uses color or shading to represent wind speeds. Wind roses are constructed by uploading hourly NWS surface wind data from the nearest weather station (with sufficient data) into a wind rose software program, WRPLOT (Lakes, 2011).

For each site, three wind roses were constructed. First, historical data were used to construct a wind rose for up to 10 years prior to the current sampling year; second, 2013 data were used to construct a wind rose presenting wind data for the entire calendar year; and lastly, a wind rose was constructed to present wind data for sample days only. These wind roses are used to determine if the meteorological conditions on days samples were collected were representative

of conditions experienced throughout the sampling year and historically near each site. In addition to the wind roses, a map showing the distance between the NWS station used and the monitoring site is presented. This allows for topographical influences on the wind patterns to potentially be identified.

3.4.3 Preliminary Risk-Based Screening and Pollutants of Interest

The preliminary risk-based screening process described in Section 3.2 and applied at the program-level was also completed for each individual monitoring site to determine site-specific pollutants of interest. Once these were determined, the time-period averages (quarterly and annual) described in Section 3.1 were calculated for each site and were used for various data analyses at the site-specific level, as described below:

- Comparison to the program-level concentrations
- Trends analysis
- The calculation of cancer risk and noncancer hazard approximations in relation to cancer and noncancer health effects, including the emission tracer analysis
- Risk-based emissions assessment.

3.4.3.1 Site-Specific Comparison to Program-level Average Concentrations

To better understand how an individual site's concentrations compare to the program-level results, as presented in Tables 4-1 through 4-6 of Section 4.1, the site-specific and program-level concentrations are presented together graphically for each site-specific pollutant of interest identified via the risk-based screening process. This analysis is an extension of the analysis discussed in Section 3.3.2 and utilizes box and whisker plots, or simply box plots, to visually show this comparison. These box plots were created in Microsoft Excel, using the Peltier Box and Whisker Plot Utility (Peltier, 2012). Note that for sites sampling VOCs (or SNMOCs), pollutants are shown only in comparison to other sites sampling VOCs (or SNMOCs) to match the program-level averages presented in Tables 4-1 and 4-2 in Section 4.1.

The box plots used in this analysis overlay the site-specific minimum, annual average, and maximum concentrations over several program-level statistical metrics. For the program-level statistics, the first, second (median), third, and fourth (maximum) quartiles are shown as colored segments on a "bar" where the color changes correspond to the exact numerical value of

the quartile. The thin vertical line represents the program-level average concentration. The site-specific annual average is shown as a white circle plotted on top of the bar and the horizontal lines extending outward from the white circle represent the minimum and maximum concentration measured at the site. An example of this figure is shown in Figure 5-4. Note that the program-level average concentrations shown for VOCs, SNMOCs, and carbonyl compounds in Tables 4-1 through 4-3 are presented in method-specific units, but have been converted to a common unit of measurement ($\mu\text{g}/\text{m}^3$) for the purposes of this analysis. These graphs are presented in Sections 5 through 30, and are grouped by pollutant within each state section. This allows for both a “site vs. program” comparison as well as an inter-site comparison for sites within a given state.

3.4.3.2 Site Trends Analysis

Table 2-1 presents current monitoring sites that have participated in the NMP in previous years. A site-specific trends analysis was conducted for sites with at least 5 consecutive years of method-specific data analyzed under the NMP. The trends analysis was conducted for each of the site-specific pollutants of interest identified via the risk-based screening process. Forty-one of the 66 sites have sampled at least one pollutant group long enough for the trends analysis to be conducted. The approach to this trends analysis is described below and the results are presented in the individual state sections (Sections 5 through 30).

The trends figures and analyses are presented as 1-year statistical metrics. The following criteria were used to calculate valid statistical metrics:

- Analysis must have been performed under the NMP by the contract laboratory.
- There must be a minimum of at least 5 years of consecutive data.

Five individual statistical metrics were calculated for this analysis and are presented as box and whisker plots, an example of which can be seen in Figure 6-16. The statistical metrics shown include the minimum and maximum concentration measured during each year (as shown by the upper and lower value of the lines extending from the box); the 5th percentile, 50th percentile (or median), and 95th percentile (as shown by the y-values corresponding with the bottom of the box, the blue line, and top of the box, respectively); and the average (or mean) concentration (as denoted by the orange diamond). Each of the five metrics represents all

measurements collected during that 1-year period. For each 1-year period, there must be a minimum of 85 percent completeness, which corresponds to roughly 51 valid samples or approximately 10 months of sampling (for a site sampling on a 1-in-6 day sampling schedule) for an average to be presented. For cases where sampling began mid-year, a minimum of 6 months of sampling is required. In these cases, the 1-year average is not provided but the concentration range and quartiles are still presented.

Data used in this analysis were downloaded from EPA's AQS database (EPA, 2014b), where non-detects are uploaded into AQS as zeros (EPA, 2009b). Similar to other analyses presented in this report, zeros representing these non-detects were incorporated into the statistical calculations. The results from sample days with precision data (duplicates, collocates, and/or replicates) were averaged together to allow for the determination of a single concentration per pollutant for each site, reflecting the data treatment described in Section 3.1.

3.4.3.3 Cancer Risk and Noncancer Hazard Approximations

Risk was further examined by calculating cancer risk and noncancer hazard approximations for each of the site-specific pollutants of interest. The cancer risk approximations presented in this report estimate the cancer risk due to exposure to a given pollutant at the annual average concentration over a 70-year period (not the risk resulting from exposure over the time period covered in this report). A cancer risk approximation less than 1 in-a-million is considered negligible; a cancer risk greater than 1 in-a-million but less than 100 in-a-million is generally considered acceptable; and a cancer risk greater than 100 in-a-million is considered significant (EPA, 2009c). The noncancer hazard approximation is presented as the Noncancer Hazard Quotient (HQ), which is a unitless value. According to EPA, "If the HQ is calculated to be equal to or less than 1.0, then no adverse health effects are expected as a result of exposure. If the HQ is greater than 1.0, then adverse health effects are possible" (EPA, 2011b).

The toxicity factors applied to calculate the cancer risk and noncancer hazard approximations are typically UREs (for cancer) or RfCs (for noncancer), which are developed by EPA. However, UREs and RfCs are not available for all pollutants. In the absence of EPA values, toxicity factors developed by agencies with credible methods and that are similar in scope and definition were used (EPA, 2014e). Cancer URE and noncancer RfC toxicity factors can be applied to the annual averages to approximate risk based on ambient monitoring data.

While the cancer risk and noncancer hazard approximations do not incorporate human activity patterns and therefore do not reflect true human inhalation exposure, they may allow analysts to further refine their focus by identifying concentrations of specific pollutants that may present health risks. Cancer UREs and/or noncancer RfCs, site-specific annual averages, and corresponding annual average-based cancer risk and noncancer hazard approximations are presented in each state section (Sections 5 through 30).

To further this analysis, pollution roses were created for each of the site-specific pollutants of interest that have cancer risk approximations greater than 75 in-a-million and/or a noncancer hazard approximation greater than 1.0, where applicable. This analysis is performed to help identify the geographical area where the emissions sources of these pollutants may have originated. A pollution rose is a plot of the ambient concentration versus the wind speed and direction; high concentrations may be shown in relation to the direction of potential emissions sources.

There are, however, limitations to this analysis. NWS wind data are hourly observations while concentrations from this report are 24-hour measurements. Thus, the wind data must be averaged for comparison to the concentrations data. Wind speed and direction can fluctuate throughout a given day or change dramatically if a frontal system moves through. Thus, the average calculated wind data may not be completely representative of a given day. This can be investigated more thoroughly if the need arises.

3.4.3.4 Risk-Based Emissions Assessment

A pollutant emitted in high quantities does not necessarily present a higher risk to human health than a pollutant emitted in very low quantities. The more toxic the pollutant, the more risk associated with its emissions in ambient air. The development of various health-based toxicity factors, as discussed in previous sections, has allowed analysts to apply weight to the emissions of pollutants based on toxicity rather than mass emissions. This approach considers both a pollutant's toxicity potential and the quantity emitted.

This assessment compares county-level emissions to toxicity-weighted emissions based on the EPA-approved approach described below (EPA, 2007). The 10 pollutants with the highest total mass emissions and the 10 pollutants with the highest associated toxicity-weighted

emissions for pollutants with cancer and noncancer toxicity factors are presented in each state section. While the *absolute magnitude* of the pollutant-specific toxicity-weighted emissions is not meaningful, the *relative magnitude* of toxicity-weighted emissions is useful in identifying the order of potential priority for air quality managers. Higher values suggest greater priority; however, even the highest values may not reflect potential cancer effects greater than the level of concern (100 in-a-million) or potential noncancer effects above the level of concern (e.g., HQ = 1.0). The pollutants exhibiting the 10 highest annual average-based risk approximations for cancer and noncancer effects are also presented in each state section. The results of this data analysis may help state, local, and tribal agencies better understand which pollutants emitted, from a toxicity basis, are of the greatest concern and whether or not these pollutants are already being monitored or perhaps should be monitored in the future.

The toxicity-weighted emissions approach consists of the following steps:

1. Obtain HAP emissions data for all anthropogenic sectors (nonpoint, point, onroad, and nonroad) from the NEI. For point sources, sum the process-level emissions to the county-level. Biogenic emissions are not included in this analysis.
2. Apply the mass extraction speciation profiles to extract metal and cyanide mass.
3. Apply weight to the emissions derived from the steps above based on their toxicity. The results of the toxicity-weighting process are unitless.
 - a. To apply weight based on cancer toxicity, multiply the emissions of each pollutant by its cancer URE.
 - b. To apply weight based on noncancer toxicity, divide the emissions of each pollutant by its noncancer RfC.

The PAHs and/or phenols measured using Method TO-13A are a sub-group of Polycyclic Organic Matter (POM). Because these compounds are often not speciated into individual compounds in the NEI, the PAHs are grouped into POM Groups in order to assess risk attributable to these pollutants (EPA, 2011c). Thus, emissions data and toxicity-weighted emissions for many of the PAHs are presented by POM Groups for this analysis. Table 3-3 presents the 22 PAHs measured by Method TO-13A and their associated POM Groups, if applicable. Table 3-3 also includes the additional phenols measured at KMMS (cresols and phenol). The POM groups are sub-grouped in Table 3-3 because toxicity research has led to the refining of UREs for certain PAHs (EPA, 2014e). Note that naphthalene, phenol, and cresols emissions are reported to the NEI individually; therefore, they are not included in one of the

POM Groups. Also note that four pollutants analyzed by Method TO-13A and listed in Table 3-3 do not have assigned POM Groups.

Table 3-3. POM Groups for PAHs and Phenols

Pollutant	POM Group	POM Subgroup
Acenaphthene	Group 2	Group 2b
Acenaphthylene	Group 2	Group 2b
Anthracene	Group 2	Group 2d
Benzo(a)anthracene	Group 6	
Benzo(a)pyrene	Group 5	Group 5a
Benzo(b)fluoranthene	Group 6	
Benzo(e)pyrene	Group 2	Group 2b
Benzo(g,h,i)perylene	Group 2	Group 2b
Benzo(k)fluoranthene	Group 6	
Chrysene	Group 7	
Coronene	NA	
Cresols*	NA	
Cyclopenta[cd]pyrene	NA	
Dibenz(a,h)anthracene	Group 5	Group 5b
Fluoranthene	Group 2	Group 2b
Fluorene	Group 2	Group 2b
9-Fluorenone	NA	
Indeno(1,2,3-cd)pyrene	Group 6	
Naphthalene*	NA	
Perylene	Group 2	Group 2b
Phenanthrene	Group 2	Group 2d
Phenol*	NA	
Pyrene	Group 2	Group 2d
Retene	NA	

* Emissions for these pollutants are reported to the NEI individually; therefore, they are not included in one of the POM Groups.

NA = no POM Group assigned.

4.0 Summary of the 2013 National Monitoring Programs Data

This section summarizes the results of the data analyses performed on the NMP dataset, as described in Section 3.

4.1 Statistical Results

This section examines the following statistical parameters for the target pollutants of each analytical method: 1) detection rates, 2) concentration ranges and data distribution, and 3) central tendency statistics. Tables 4-1 through 4-6 present statistical summaries for the target pollutants and Sections 4.1.1 through 4.1.3 review the basic findings of these statistical calculations.

4.1.1 Target Pollutant Detection Rates

There is an experimentally determined MDL for every target pollutant, as described in Section 2.2. Quantification below the MDL is possible, although the measurement's reliability is lower. If a concentration does not exceed the MDL, it does not mean that the pollutant is not present in the air. If the instrument does not generate a numerical concentration, the measurement is marked as "ND," or "non-detect." As explained in Section 2.2, data analysts should exercise caution when interpreting monitoring data with a high percentage of reported concentrations at levels near or below the corresponding MDLs. A thorough review of the number of measured detections, the number of non-detects, and the total number of samples is beneficial to understanding the representativeness of the interpretations made.

Tables 4-1 through 4-6 summarize the number of times each target pollutant was detected out of the number of valid samples collected and analyzed. Approximately 53 percent of the reported measurements (based on the preprocessed daily measurements) were greater than the MDLs across the program. The following list provides the percentage of measurements that were above the MDLs for each analytical method:

- 42.2 percent for VOCs
- 49.9 percent for SNMOCs
- 83.0 percent for carbonyl compounds
- 61.4 percent for PAHs and 54.4 percent for PAHs/Phenols
- 77.1 percent for metals

- 38.7 percent for hexavalent chromium samples.

Some pollutants were detected in every sample collected while others were infrequently detected or not detected at all. Among the carbonyl compounds, formaldehyde and acetone had the greatest number of measured detections (1,758), based on the preprocessed daily measurements. These pollutants were reported in every valid carbonyl compound sample collected (1,758). Six VOCs, (benzene, toluene, chloromethane, dichlorodifluoromethane, propylene, and trichlorotrifluoromethane) were detected in every valid VOC sample collected (1,883). Thirteen pollutants, including acetylene, ethylene, ethane, and propylene, were detected in every valid SNMOC sample collected (364). Naphthalene, phenanthrene, fluoranthene, and pyrene were detected in every valid PAH or PAH/Phenol sample collected (1,340). Lead, manganese, antimony, cadmium, and cobalt were detected in every valid metal sample collected (1,090). Hexavalent chromium was detected in 290 samples (out of 744 valid samples).

Although NBIL and BTUT have the greatest number of measured detections (6,690 for NBIL and 6,469 for BTUT), they were also the only two sites that collected samples for all six analytical methods/pollutant groups. However, the detection rates for these sites (61 percent and 67 percent, respectively) were not as high as other sites. Detection rates for sites that sampled suites of pollutants that are frequently detected tended to be higher (refer to the list of method-specific percentages of measurements above the MDL listed above). For example, metals were rarely reported as non-detects. As a result, sites that sampled only metals (such as PAFL) would be expected to have higher detection rates. PAFL's detection rate is 100 percent. Conversely, VOCs had one of the lowest percentages of concentrations greater than the MDLs (42.2 percent). A site measuring only VOCs would be expected to have lower detection rates, such as SPAZ (48.9 percent).

Table 4-1. Statistical Summaries of the VOC Concentrations

Pollutant	# of Non-Detects ¹	# of Measured Detections ¹	# of Measured Detections <MDL	Minimum ² (ppbv)	Maximum (ppbv)	Arithmetic Mean (ppbv)	Median (ppbv)	First Quartile (ppbv)	Third Quartile (ppbv)	Standard Deviation (ppbv)
Acetonitrile	6	1,877	2	0.029	653	10.1	0.253	0.113	0.964	50.6
Acetylene	7	1,876	0	0.046	29.2	0.849	0.497	0.308	0.820	1.41
Acrolein	200	1,683	0	0.057	3.62	0.347	0.292	0.171	0.485	0.271
Acrylonitrile	1,484	399	0	0.034	1.59	0.054	0	0	0	0.157
<i>tert</i> -Amyl Methyl Ether	1,842	41	41	0.006	0.012	<0.001	0	0	0	0.001
Benzene	0	1,883	0	0.025	13.6	0.245	0.188	0.135	0.268	0.364
Bromochloromethane	1,882	1	1	0.008	0.008	<0.001	0	0	0	0.000
Bromodichloromethane	1,728	155	113	0.005	8.36	0.009	0	0	0	0.205
Bromoform	1,704	179	176	0.004	0.166	0.001	0	0	0	0.005
Bromomethane	479	1,404	344	0.006	3.37	0.014	0.011	0	0.014	0.087
1,3-Butadiene	304	1,579	26	0.006	9.69	0.070	0.027	0.016	0.044	0.453
Carbon Disulfide	22	1,861	444	0.003	22.7	0.477	0.018	0.011	0.096	1.38
Carbon Tetrachloride	1	1,882	1	0.009	3.76	0.104	0.101	0.093	0.110	0.086
Chlorobenzene	1,820	63	53	0.004	0.074	<0.001	0	0	0	0.004
Chloroethane	1,641	242	1	0.010	2.35	0.007	0	0	0	0.072
Chloroform	405	1,478	25	0.009	19.4	0.048	0.0228	0.016	0.030	0.503
Chloromethane	0	1,883	0	0.134	3.39	0.562	0.545	0.494	0.606	0.124
Chloroprene	1,880	3	1	0.008	0.178	<0.001	0	0	0	0.004
Dibromochloromethane	1,029	854	835	0.001	3.08	0.005	0	0	0.006	0.074
1,2-Dibromoethane	1,869	14	14	0.005	0.012	<0.001	0	0	0	0.001
<i>m</i> -Dichlorobenzene	1,692	191	177	0.004	0.178	0.001	0	0	0	0.006
<i>o</i> -Dichlorobenzene	1,699	184	184	0.003	0.020	0.001	0	0	0	0.002
<i>p</i> -Dichlorobenzene	978	905	768	0.003	0.113	0.007	0	0	0.011	0.011
Dichlorodifluoromethane	0	1,883	0	0.092	0.776	0.508	0.510	0.450	0.557	0.072
1,1-Dichloroethane	1,853	30	5	0.011	1.09	0.001	0	0	0	0.026
1,2-Dichloroethane	278	1,605	170	0.010	27.3	0.065	0.021	0.016	0.027	0.674

¹ Out of 1,883 valid samples

² Excludes zeros for non-detects

³ The total number of concentrations may not add up to 1,883 for some compounds where no value could be reported due to co-elution.

Table 4-1. Statistical Summaries of the VOC Concentrations (Continued)

Pollutant	# of Non-Detects¹	# of Measured Detections¹	# of Measured Detections <MDL	Minimum² (ppbv)	Maximum (ppbv)	Arithmetic Mean (ppbv)	Median (ppbv)	First Quartile (ppbv)	Third Quartile (ppbv)	Standard Deviation (ppbv)
1,1-Dichloroethene	1,786	97	80	0.004	0.099	0.001	0	0	0	0.003
<i>cis</i> -1,2-Dichloroethylene	1,880	3	0	0.054	0.211	<0.001	0	0	0	0.005
<i>trans</i> -1,2-Dichloroethylene	1,845	38	3	0.009	0.152	0.001	0	0	0	0.005
Dichloromethane ³	25	1,791	0	0.045	1610	2.35	0.141	0.100	0.257	40.7
1,2-Dichloropropane	1,881	2	2	0.011	0.013	<0.001	0	0	0	0.000
<i>cis</i> -1,3-Dichloropropene	1,877	6	0	0.015	0.070	<0.001	0	0	0	0.002
<i>trans</i> -1,3-Dichloropropene	1,880	3	0	0.026	0.061	<0.001	0	0	0	0.002
Dichlorotetrafluoroethane	1	1,882	1	0.006	0.037	0.017	0.017	0.015	0.019	0.003
Ethyl Acrylate	1,872	11	2	0.013	0.058	<0.001	0	0	0	0.002
Ethyl <i>tert</i> -Butyl Ether	1,579	304	12	0.005	0.894	0.010	0	0	0	0.032
Ethylbenzene	6	1,877	153	0.006	4.30	0.082	0.048	0.029	0.080	0.200
Hexachloro-1,3-butadiene	1,553	330	330	0.003	0.027	0.001	0	0	0	0.003
Methyl Isobutyl Ketone	164	1,719	258	0.006	0.512	0.035	0.028	0.018	0.044	0.033
Methyl Methacrylate	1,724	159	42	0.005	0.244	0.003	0	0	0	0.013
Methyl <i>tert</i> -Butyl Ether	1,473	410	30	0.004	7.19	0.041	0	0	0	0.355
<i>n</i> -Octane	111	1,772	43	0.006	2.55	0.052	0.030	0.019	0.051	0.118
Propylene	0	1,883	1	0.030	89.6	0.688	0.339	0.228	0.533	2.93
Styrene	406	1,477	382	0.005	32.8	0.076	0.021	0.011	0.038	0.774
1,1,2,2-Tetrachloroethane	1,610	273	235	0.004	0.171	0.002	0	0	0	0.010
Tetrachloroethylene	430	1,453	616	0.004	1.96	0.020	0.012	0.006	0.022	0.059
Toluene	0	1,883	3	0.010	8.55	0.489	0.301	0.163	0.555	0.653
1,2,4-Trichlorobenzene	1,856	27	22	0.004	0.050	<0.001	0	0	0	0.002
1,1,1-Trichloroethane	518	1,365	1,338	0.004	0.085	0.007	0.007	0	0.010	0.005
1,1,2-Trichloroethane	1,854	29	18	0.006	0.394	0.001	0	0	0	0.010
Trichloroethylene	1,575	308	168	0.005	0.596	0.004	0	0	0	0.020
Trichlorofluoromethane	0	1,883	0	0.050	1.69	0.263	0.252	0.230	0.282	0.069
Trichlorotrifluoroethane	1	1,882	0	0.019	0.129	0.083	0.083	0.076	0.089	0.009

¹ Out of 1,883 valid samples

² Excludes zeros for non-detects

³ The total number of concentrations may not add up to 1,883 for some compounds where no value could be reported due to co-elution.

Table 4-1. Statistical Summaries of the VOC Concentrations (Continued)

Pollutant	# of Non-Detects¹	# of Measured Detections¹	# of Measured Detections <MDL	Minimum² (ppbv)	Maximum (ppbv)	Arithmetic Mean (ppbv)	Median (ppbv)	First Quartile (ppbv)	Third Quartile (ppbv)	Standard Deviation (ppbv)
1,2,4-Trimethylbenzene	74	1,809	249	0.004	38.7	0.100	0.041	0.023	0.073	0.940
1,3,5-Trimethylbenzene	277	1,606	704	0.003	10.8	0.035	0.018	0.010	0.029	0.268
Vinyl chloride	1,640	243	54	0.005	2.37	0.015	0	0	0	0.122
<i>m,p</i> -Xylene	1	1,882	91	0.005	20.0	0.243	0.114	0.065	0.207	0.939
<i>o</i> -Xylene	15	1,868	168	0.006	8.08	0.095	0.048	0.028	0.085	0.340

¹ Out of 1,883 valid samples

² Excludes zeros for non-detects

³ The total number of concentrations may not add up to 1,883 for some compounds where no value could be reported due to co-elution.

Table 4-2. Statistical Summaries of the SNMOC Concentrations

Pollutant	# of Non-Detects ¹	# of Measured Detections ¹	# of Measured Detections <MDL ¹	Minimum ² (ppbC)	Maximum (ppbC)	Arithmetic Mean (ppbC)	Median (ppbC)	First Quartile (ppbC)	Third Quartile (ppbC)	Standard Deviation (ppbC)
Acetylene	0	364	15	0.142	10.8	1.37	0.912	0.519	1.54	1.43
Benzene ³	1	338	0	0.297	10.2	2.25	1.77	1.24	2.70	1.66
1,3-Butadiene	244	120	73	0.076	0.995	0.067	0	0	0.110	0.125
<i>n</i> -Butane	0	364	0	0.405	135	13.7	8.80	5.00	15.0	16.6
1-Butene ³	3	1	0	0.760	0.760	0.190	0	0	0.190	0.329
<i>cis</i> -2-Butene	210	154	28	0.055	0.903	0.099	0	0	0.147	0.161
<i>trans</i> -2-Butene	182	182	6	0.074	2.39	0.156	0.037	0	0.216	0.246
Cyclohexane	6	358	14	0.082	28.5	3.30	2.50	0.784	3.81	3.77
Cyclopentane ³	63	300	0	0.078	3.83	0.512	0.418	0.248	0.603	0.514
Cyclopentene	355	9	4	0.097	0.922	0.007	0	0	0	0.060
<i>n</i> -Decane	23	341	25	0.104	8.46	0.728	0.543	0.309	0.901	0.769
1-Decene	364	0	0	Not Detected						
<i>m</i> -Diethylbenzene	349	15	0	0.321	9.43	0.066	0	0	0	0.565
<i>p</i> -Diethylbenzene	332	32	4	0.139	2.94	0.058	0	0	0	0.256
2,2-Dimethylbutane	58	306	3	0.083	3.12	0.418	0.322	0.167	0.490	0.443
2,3-Dimethylbutane	7	357	18	0.064	6.84	0.821	0.607	0.319	0.909	0.859
2,3-Dimethylpentane	9	355	84	0.106	9.54	0.794	0.534	0.353	0.925	0.884
2,4-Dimethylpentane	34	330	181	0.080	1.87	0.342	0.264	0.167	0.416	0.294
<i>n</i> -Dodecane	47	317	214	0.071	10.9	0.386	0.202	0.121	0.381	0.758
1-Dodecene	359	5	0	0.228	1.26	0.009	0	0	0	0.086
Ethane	0	364	0	3.75	493	56.2	34.7	12.3	59.4	75.6
2-Ethyl-1-butene	364	0	0	Not Detected						
Ethylbenzene	37	327	19	0.090	11.1	0.458	0.318	0.182	0.524	0.787
Ethylene	0	364	0	0.452	14.7	2.91	2.37	1.75	3.24	1.93
<i>m</i> -Ethyltoluene	77	287	0	0.132	152	1.20	0.485	0.215	0.852	8.23
<i>o</i> -Ethyltoluene	212	152	7	0.107	58.8	0.415	0	0	0.305	3.25

¹ Out of 364 valid samples.

² Excludes zeros for non-detects.

³ The total number of concentrations may not add up to 364 for some compounds where no value could be reported due to co-elution.

NA = Not applicable for these parameters.

Table 4-2. Statistical Summaries of the SNMOC Concentrations (Continued)

Pollutant	# of Non-Detects ¹	# of Measured Detections ¹	# of Measured Detections <MDL ¹	Minimum ² (ppbC)	Maximum (ppbC)	Arithmetic Mean (ppbC)	Median (ppbC)	First Quartile (ppbC)	Third Quartile (ppbC)	Standard Deviation (ppbC)
<i>p</i> -Ethyltoluene	127	237	37	0.091	72.8	0.593	0.245	0	0.471	3.94
<i>n</i> -Heptane	0	364	3	0.086	36.1	3.07	2.24	0.962	3.38	3.63
1-Heptene	358	6	4	0.103	1.12	0.006	0	0	0	0.063
<i>n</i> -Hexane	0	364	8	0.157	32.2	3.79	2.90	1.33	4.09	4.00
1-Hexene	295	69	65	0.056	1.56	0.032	0	0	0	0.123
<i>cis</i> -2-Hexene	360	4	4	0.067	0.112	0.001	0	0	0	0.009
<i>trans</i> -2-Hexene	349	15	14	0.062	0.256	0.005	0	0	0	0.024
Isobutane	0	364	0	0.229	122	12.1	7.57	2.83	13.8	15.8
Isobutylene ³	2	11	2	0.155	0.477	0.220	0.227	0.181	0.278	0.122
Isopentane ³	9	218	0	0.514	89.8	13.7	9.95	3.67	17.4	14.3
Isoprene	132	232	90	0.052	9.62	0.657	0.143	0	0.749	1.23
Isopropylbenzene	309	55	33	0.083	7.18	0.050	0	0	0	0.389
2-Methyl-1-butene	195	169	61	0.069	0.904	0.115	0	0	0.211	0.150
3-Methyl-1-butene	360	4	0	0.240	0.983	0.008	0	0	0	0.080
2-Methyl-1-pentene	362	2	2	0.108	0.181	0.001	0	0	0	0.011
4-Methyl-1-pentene	364	0	0	Not Detected						
2-Methyl-2-butene ³	192	171	41	0.081	1.46	0.158	0	0	0.253	0.227
Methylcyclohexane ³	20	343	13	0.118	45.7	6.00	4.37	1.04	7.92	6.96
Methylcyclopentane	4	360	4	0.106	14.9	1.99	1.53	0.650	2.28	2.04
2-Methylheptane	65	299	38	0.077	5.43	0.695	0.524	0.161	0.898	0.793
3-Methylheptane	49	315	44	0.084	4.82	0.553	0.399	0.169	0.731	0.611
2-Methylhexane	2	362	0	0.206	21.3	2.38	1.83	1.19	2.92	2.11
3-Methylhexane ³	68	257	4	0.298	31.8	1.98	1.46	0.698	2.34	2.73
2-Methylpentane	0	364	0	0.298	29.9	3.75	2.95	1.51	4.27	3.62
3-Methylpentane	2	362	4	0.086	16.0	1.97	1.51	0.740	2.26	2.01
<i>n</i> -Nonane	16	348	7	0.078	6.69	0.777	0.540	0.286	0.984	0.841

¹ Out of 364 valid samples.

² Excludes zeros for non-detects.

³ The total number of concentrations may not add up to 364 for some compounds where no value could be reported due to co-elution.

NA = Not applicable for these parameters.

Table 4-2. Statistical Summaries of the SNMOC Concentrations (Continued)

Pollutant	# of Non-Detects ¹	# of Measured Detections ¹	# of Measured Detections <MDL ¹	Minimum ² (ppbC)	Maximum (ppbC)	Arithmetic Mean (ppbC)	Median (ppbC)	First Quartile (ppbC)	Third Quartile (ppbC)	Standard Deviation (ppbC)
1-Nonene	179	185	97	0.071	5.23	0.162	0.074	0	0.181	0.446
<i>n</i> -Octane	2	362	38	0.091	17.7	1.81	1.24	0.586	2.25	2.06
1-Octene	83	281	70	0.084	2.21	0.267	0.228	0.115	0.360	0.256
<i>n</i> -Pentane	0	364	0	0.399	80.6	7.97	5.29	2.86	8.62	9.40
1-Pentene	48	316	181	0.066	4.38	0.260	0.156	0.103	0.228	0.541
<i>cis</i> -2-Pentene	275	89	80	0.058	0.293	0.031	0	0	0	0.061
<i>trans</i> -2-Pentene	160	204	89	0.061	0.688	0.117	0.083	0	0.202	0.137
<i>a</i> -Pinene	176	188	25	0.088	5.05	0.311	0.137	0	0.416	0.526
<i>b</i> -Pinene	363	1	0	1.48	1.48	0.004	0	0	0	0.077
Propane	0	364	0	1.23	333	34.4	21.3	9.96	36.3	44.2
<i>n</i> -Propylbenzene	175	189	18	0.085	40.5	0.314	0.117	0	0.275	2.18
Propylene	0	364	0	0.189	5.91	0.971	0.748	0.501	1.11	0.808
Propyne	362	2	1	0.062	0.539	0.002	0	0	0	0.028
Styrene ³	138	80	4	0.141	48.6	4.07	0	0	5.76	8.05
Toluene	0	364	0	0.500	49.4	7.12	5.49	3.29	8.55	6.18
<i>n</i> -Tridecane	217	147	89	0.065	2.40	0.105	0	0	0.128	0.241
1-Tridecene	364	0	0	Not Detected						
1,2,3-Trimethylbenzene	165	199	28	0.089	31.3	0.308	0.131	0	0.256	1.82
1,2,4-Trimethylbenzene	1	363	3	0.138	214	1.89	0.804	0.490	1.25	11.9
1,3,5-Trimethylbenzene	100	264	54	0.094	67.2	0.561	0.249	0	0.443	3.69
2,2,3-Trimethylpentane	171	193	27	0.098	1.27	0.184	0.148	0	0.289	0.228
2,2,4-Trimethylpentane ³	209	149	10	0.101	9.18	0.457	0	0	0.523	0.965
2,3,4-Trimethylpentane	100	264	18	0.083	3.90	0.348	0.240	0	0.416	0.491
<i>n</i> -Undecane	37	327	107	0.078	6.77	0.402	0.274	0.164	0.492	0.526
1-Undecene	348	16	9	0.086	1.50	0.013	0	0	0	0.092
<i>m</i> -Xylene/ <i>p</i> -Xylene	0	364	0	0.180	33.2	2.28	1.75	0.977	2.69	2.64

¹ Out of 364 valid samples.

² Excludes zeros for non-detects.

³ The total number of concentrations may not add up to 364 for some compounds where no value could be reported due to co-elution.

NA = Not applicable for these parameters.

Table 4-2. Statistical Summaries of the SNMOC Concentrations (Continued)

Pollutant	# of Non-Detects¹	# of Measured Detections¹	# of Measured Detections <MDL¹	Minimum² (ppbC)	Maximum (ppbC)	Arithmetic Mean (ppbC)	Median (ppbC)	First Quartile (ppbC)	Third Quartile (ppbC)	Standard Deviation (ppbC)
<i>o</i> -Xylene	5	359	0	0.110	12.8	0.684	0.498	0.334	0.770	0.957
SNMOC (Sum of Knowns)	NA	NA	NA	14.9	1,530	199	144	77.3	206	214
Sum of Unknowns	NA	NA	NA	16.5	1,800	167	91.9	58.0	181	220
TNMOC	NA	NA	NA	56.1	1,970	366	270	176	427	304

¹ Out of 364 valid samples.

² Excludes zeros for non-detects.

³ The total number of concentrations may not add up to 364 for some compounds where no value could be reported due to co-elution.

NA = Not applicable for these parameters.

Table 4-3. Statistical Summaries of the Carbonyl Compound Concentrations

Pollutant	# of Non-Detects¹	# of Measured Detections¹	# of Measured Detections <MDL¹	Minimum² (ppbv)	Maximum (ppbv)	Arithmetic Mean (ppbv)	Median (ppbv)	First Quartile (ppbv)	Third Quartile (ppbv)	Standard Deviation (ppbv)
Acetaldehyde ³	0	1,756	0	0.006	7.87	0.996	0.823	0.536	1.25	0.698
Acetone	0	1,758	0	0.024	7.45	1.12	0.887	0.568	1.37	0.884
Benzaldehyde ³	10	1,740	0	0.002	1.82	0.046	0.023	0.014	0.037	0.128
2-Butanone ³	4	1,726	0	0.007	12.8	0.207	0.132	0.083	0.229	0.418
Butyraldehyde ³	4	1,744	0	0.003	2.71	0.104	0.075	0.046	0.122	0.122
Crotonaldehyde ³	21	1,728	0	0.005	2.13	0.125	0.047	0.025	0.152	0.187
2,5-Dimethylbenzaldehyde	1,758	0	0	Not Detected						
Formaldehyde	0	1,758	0	0.010	17.8	2.30	1.78	1.10	2.97	1.90
Hexaldehyde ³	20	1,726	0	0.002	0.893	0.043	0.022	0.012	0.041	0.085
Isovaleraldehyde	1,755	3	0	0.047	0.160	<0.001	0	0	0	0.005
Propionaldehyde ³	12	1,744	0	0.004	0.811	0.131	0.102	0.064	0.168	0.103
Tolualdehydes ³	211	1,412	11	0.002	0.460	0.026	0.018	0.009	0.031	0.036
Valeraldehyde ³	46	1,668	0	0.002	0.511	0.035	0.022	0.013	0.037	0.051

¹ Out of 1,758 valid samples.

² Excludes zeros for non-detects.

³ The total number of concentrations may not add up to 1,758 for some compounds where no value could be reported due to co-elution.

Table 4-4a. Statistical Summaries of the PAH Concentrations

Pollutant	# of Non-Detects ¹	# of Measured Detections ¹	# of Measured Detections <MDL ¹	Minimum ² (ng/m ³)	Maximum (ng/m ³)	Arithmetic Mean (ng/m ³)	Median (ng/m ³)	First Quartile (ng/m ³)	Third Quartile (ng/m ³)	Standard Deviation (ng/m ³)
Acenaphthene	19	1,291	0	0.079	123	4.89	2.01	0.945	4.14	10.4
Acenaphthylene	635	675	4	0.025	23.4	0.751	0.075	0	0.548	1.98
Anthracene	205	1,105	4	0.022	18.4	0.407	0.225	0.108	0.449	0.843
Benzo(a)anthracene	368	942	578	0.014	2.40	0.093	0.043	0	0.100	0.187
Benzo(a)pyrene	439	871	382	0.015	2.17	0.086	0.041	0	0.100	0.161
Benzo(b)fluoranthene	118	1,192	235	0.019	3.11	0.216	0.116	0.047	0.264	0.311
Benzo(e)pyrene	233	1,077	446	0.006	1.42	0.108	0.061	0.027	0.137	0.147
Benzo(g,h,i)perylene	228	1,082	282	0.015	4.27	0.127	0.062	0.030	0.144	0.216
Benzo(k)fluoranthene	565	745	384	0.014	0.933	0.053	0.028	0	0.068	0.092
Chrysene	69	1,241	43	0.015	2.89	0.206	0.137	0.067	0.247	0.267
Coronene	599	711	381	0.016	3.23	0.050	0.024	0	0.060	0.122
Cyclopenta[cd]pyrene	1,064	246	76	0.015	1.92	0.029	0	0	0	0.118
Dibenz(a,h)anthracene	1,081	229	143	0.006	0.226	0.008	0	0	0	0.022
Fluoranthene	0	1,310	0	0.069	52.4	2.36	1.33	0.742	2.49	3.58
Fluorene	172	1,138	0	0.305	99.1	4.66	2.78	1.36	5.03	7.69
9-Fluorenone	2	1,308	0	0.093	14.3	1.43	1.05	0.592	1.78	1.37
Indeno(1,2,3-cd)pyrene	369	941	169	0.019	1.66	0.103	0.058	0	0.126	0.158
Naphthalene	0	1,310	0	1.95	748	75.3	54.1	27.6	94.7	73.0
Perylene	1,007	303	189	0.007	0.411	0.012	0	0	0	0.031
Phenanthrene	0	1,310	0	0.294	290	9.86	5.25	2.78	10.2	17.9
Pyrene	0	1,310	6	0.031	29.7	1.41	0.845	0.462	1.53	1.97
Retene	55	1,255	585	0.015	26.5	0.353	0.118	0.072	0.281	0.992

¹ Out of 1,310 valid samples.² Excludes zeros for non-detects.

Table 4-4b. Statistical Summaries of the PAH/Phenols Concentrations

Pollutant	# of Non-Detects ¹	# of Measured Detections ¹	# of Measured Detections <MDL ¹	Minimum ² (ng/m ³)	Maximum (ng/m ³)	Arithmetic Mean (ng/m ³)	Median (ng/m ³)	First Quartile (ng/m ³)	Third Quartile (ng/m ³)	Standard Deviation (ng/m ³)
Acenaphthene	0	30	0	1.56	40.3	17.4	15.8	9.39	23.0	10.7
Anthracene	8	22	2	0.126	1.81	0.504	0.484	0.032	0.773	0.443
Benzo(a)anthracene	24	6	5	0.019	0.221	0.014	0	0	0	0.042
Benzo(a)pyrene	28	2	2	0.030	0.057	0.003	0	0	0	0.011
Benzo(b)fluoranthene	5	25	24	0.035	0.389	0.063	0.057	0.036	0.075	0.068
Benzo(g,h,i)perylene	15	15	15	0.029	0.142	0.025	0.014	0	0.041	0.031
Benzo(k)fluoranthene	28	2	2	0.044	0.100	0.005	0	0	0	0.019
Chrysene	0	30	28	0.038	0.447	0.136	0.123	0.081	0.159	0.080
<i>m,p</i> -Cresols	0	30	0	4.13	25.8	9.88	8.22	5.70	11.5	5.90
<i>o</i> -Cresol	0	30	0	3.41	12.0	6.38	5.92	4.53	7.28	2.47
Dibenz(a,h)anthracene	30	0	0	Not Detected						
Fluoranthene	0	30	0	0.558	12.1	5.46	4.85	3.45	7.42	3.20
Fluorene	0	30	0	1.20	23.6	10.6	9.46	6.28	13.4	6.13
Indeno(1,2,3-cd)pyrene	26	4	4	0.034	0.151	0.009	0	0	0	0.029
Naphthalene	0	30	0	22.1	281	116	107	59.8	148	69.1
Phenanthrene	0	30	0	2.71	52.8	24.5	21.9	15.4	31.3	13.6
Phenol	0	30	0	24.9	1245	250	174	92.2	249	264
Pyrene	0	30	0	0.285	4.64	1.98	1.70	1.30	2.65	1.11

¹ Out of 30 valid samples.

² Excludes zeros for non-detects.

Table 4-5. Statistical Summaries of the Metals Concentrations

Pollutant	# of Non-Detects ¹	# of Measured Detections ¹	# of Measured Detections <MDL ¹	Minimum ² (ng/m ³)	Maximum (ng/m ³)	Arithmetic Mean (ng/m ³)	Median (ng/m ³)	First Quartile (ng/m ³)	Third Quartile (ng/m ³)	Standard Deviation (ng/m ³)
PM₁₀ Metals										
Antimony	0	799	4	0.010	18.6	1.40	0.883	0.450	1.61	1.72
Arsenic	13	786	90	0.003	9.18	0.673	0.490	0.286	0.840	0.720
Beryllium	92	707	485	0.000002	0.255	0.011	0.008	0.003	0.015	0.016
Cadmium	0	799	3	0.007	120	0.315	0.085	0.050	0.140	4.25
Chromium	122	677	625	0.003	10.8	2.05	1.36	0.200	3.21	2.24
Cobalt	0	799	51	0.002	1.95	0.126	0.070	0.040	0.154	0.158
Lead	0	799	0	0.220	49.9	3.57	2.26	1.38	3.77	4.28
Manganese	0	799	0	0.400	112	7.87	4.84	2.67	9.19	9.43
Mercury	28	771	364	0.00005	0.100	0.017	0.013	0.009	0.020	0.014
Nickel	1	798	182	0.008	21.2	1.09	0.733	0.395	1.29	1.39
Selenium	52	747	242	0.0004	6.97	0.562	0.395	0.184	0.753	0.629
TSP Metals										
Antimony	0	291	0	0.100	3.10	0.662	0.558	0.378	0.815	0.441
Arsenic	0	291	0	0.083	2.25	0.612	0.562	0.373	0.791	0.327
Beryllium	0	291	6	0.0008	0.091	0.017	0.012	0.007	0.020	0.016
Cadmium	0	291	0	0.029	2.39	0.179	0.127	0.092	0.205	0.213
Chromium	0	291	205	0.866	6.71	2.11	1.87	1.50	2.42	0.918
Cobalt	0	291	0	0.047	7.28	0.365	0.228	0.137	0.384	0.544
Lead	0	291	0	0.636	16.4	3.48	2.80	1.95	4.19	2.28
Manganese	0	291	0	0.835	75.6	17.2	13.2	7.41	22.0	13.5
Mercury	0	291	3	0.002	0.092	0.016	0.014	0.011	0.019	0.010
Nickel	0	291	178	0.291	11.0	1.30	0.989	0.670	1.56	1.04
Selenium	0	291	0	0.086	2.16	0.669	0.607	0.320	0.928	0.419

¹ For PM₁₀, out of 799 valid samples; for TSP, out of 291 valid samples.

² Excludes zeros for non-detects.

Table 4-6. Statistical Summary of the Hexavalent Chromium Concentrations

Pollutant	# of Non-Detects¹	# of Measured Detections¹	# of Measured Detections <MDL¹	Minimum² (ng/m³)	Maximum (ng/m³)	Arithmetic Mean (ng/m³)	Median (ng/m³)	First Quartile (ng/m³)	Third Quartile (ng/m³)	Standard Deviation (ng/m³)
Hexavalent Chromium	454	290	2	0.0027	0.380	0.014	0	0	0.021	0.026

¹ Out of 744 valid samples.

² Excludes zeros for non-detects.

4.1.2 Concentration Range and Data Distribution

The concentrations measured during the 2013 NMP exhibit a wide range of variability. The minimum and maximum concentration measured (excluding zeros substituted for non-detects) for each target pollutant are presented in Tables 4-1 through 4-6 (in respective pollutant group units). Some pollutants, such as dichloromethane, had a wide range of concentrations measured, while other pollutants, such as dichlorotetrafluoroethane, did not, even though they were both detected frequently. The pollutant for each method-specific pollutant group with the largest range in measured concentrations is as follows:

- For VOCs, dichloromethane (0.045 ppbv to 1,610 ppbv)
- For SNMOCs, ethane (3.75 ppbC to 493 ppbC)
- For carbonyl compounds, formaldehyde (0.010 ppbv to 17.8 ppbv)
- For PAHs, naphthalene (1.95 ng/m³ to 748 ng/m³)
- For PAHs/Phenols measured at KMMS, phenol (24.9 ng/m³ to 1,245 ng/m³)
- For metals in PM₁₀, cadmium (0.007 ng/m³ to 120 ng/m³)
- For metals in TSP, manganese (0.835 ng/m³ to 75.58 ng/m³)
- For hexavalent chromium, 0.0027 ng/m³ to 0.38 ng/m³.

4.1.3 Central Tendency

In addition to the number of measured detections and the concentration ranges, Tables 4-1 through 4-6 also present a number of central tendency and data distribution statistics (arithmetic mean, median, first and third quartiles, and standard deviation) for each of the pollutants sampled during the 2013 NMP in respective pollutant group units. A multitude of observations can be made from these tables. The pollutants with the three highest average concentrations for each pollutant group are provided below, with respective confidence intervals (although the 95 percent confidence intervals are not provided in the tables).

The top three VOCs by average concentration, as presented in Table 4-1, are:

- Acetonitrile (10.1 ± 2.29 ppbv)
- Dichloromethane (2.35 ± 1.87 ppbv).
- Acetylene (0.849 ± 0.064 ppbv)

The top three SNMOCs by average concentration, as presented in Table 4-2, are:

- Ethane (56.2 ± 7.79 ppbC)
- Propane (34.4 ± 4.55 ppbC)
- *n*-Butane (13.7 ± 1.71 ppbC).

The top three carbonyl compounds by average concentration, as presented in Table 4-3 are:

- Formaldehyde (2.30 ± 0.089 ppbv)
- Acetone (1.12 ± 0.041 ppbv).
- Acetaldehyde (0.996 ± 0.033 ppbv)

The top three PAHs by average concentration, as presented in Tables 4-4a, are:

- Naphthalene (75.3 ± 3.96 ng/m³)
- Phenanthrene (9.86 ± 0.97 ng/m³)
- Acenaphthene (4.49 ± 0.56 ng/m³).

The top three PAHs/Phenols by average concentration for KMMS, as presented in Tables 4-4b, are:

- Phenol (250 ± 98.6 ng/m³)
- Naphthalene (116 ± 25.8 ng/m³)
- Phenanthrene (24.5 ± 5.07 ng/m³).

The top three metals by average concentration for both PM₁₀ and TSP fractions, as presented in Table 4-5, are;

- Manganese (PM₁₀ = 7.87 ± 0.65 ng/m³, TSP = 17.2 ± 1.56 ng/m³)
- Lead (PM₁₀ = 3.57 ± 0.30 ng/m³, TSP = 3.48 ± 0.26 ng/m³)
- Total chromium (PM₁₀ = 2.05 ± 0.16 ng/m³, TSP = 2.11 ± 0.11 ng/m³).

The average concentration of hexavalent chromium, as presented in Table 4-6, is 0.014 ± 0.002 ng/m³.

Appendices J through O present statistical calculations on a site-specific basis, similar to those presented in Tables 4-1 through 4-6.

4.2 Preliminary Risk-Based Screening and Pollutants of Interest

Based on the preliminary risk-based screening process described in Section 3.2, Table 4-7 identifies the pollutants that failed at least one screen; summarizes each pollutant's total number of measured detections, percentage of screens failed, and cumulative percentage of failed screens; and highlights those pollutants contributing to the top 95 percent of failed screens (shaded in gray) and thereby designated as program-wide pollutants of interest.

The results in Table 4-7 are listed in descending order by number of screens failed. Table 4-7 shows that benzene failed the greatest number of screens (2,121), although carbon tetrachloride, formaldehyde, acetaldehyde, 1,2-dichloroethane, and 1,3-butadiene each failed greater than 1,500 screens. These pollutants were also among those with the greatest number of measured detections among pollutants shown in Table 4-7. Conversely, four pollutants listed in Table 4-7 failed only one screen each (bromoform, *cis*-1,3-dichloropropene, styrene, and *trans*-1,3-dichloropropene). The number of measured detections for these four pollutants varied significantly. Styrene was detected in 1,555 samples (out of 2,247 samples) while bromoform was detected less frequently (179 out of 1,883 valid samples) and *cis*-1,3-dichloropropene and *trans*-1,3-dichloropropene were rarely detected. Three pollutants exhibited a failure rate of 100 percent (1,2-dichloroethane, 1,2-dibromoethane, and chloroprene); however, chloroprene and 1,2-dibromoethane were detected in less than 1 percent of samples collected. Thus, the

number of failed screens, the number of measured detections, and the failure rate must all be considered when reviewing the results of the preliminary risk-based screening process.

Table 4-7. Results of the Program-Level Preliminary Risk-Based Screening Process

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Failed Screens	% of Total Failures	Cumulative % Contribution
Benzene	0.13	2,121	2,123	99.91	14.71	14.71
Carbon Tetrachloride	0.17	1,877	1,882	99.73	13.01	27.72
Formaldehyde	0.077	1,752	1,758	99.66	12.15	39.87
Acetaldehyde	0.45	1,678	1,756	95.56	11.63	51.50
1,2-Dichloroethane	0.038	1,605	1,605	100.00	11.13	62.63
1,3-Butadiene	0.03	1,574	1,651	95.34	10.91	73.54
Naphthalene	0.029	998	1,340	74.48	6.92	80.46
Arsenic	0.00023	925	1,077	85.89	6.41	86.88
Ethylbenzene	0.4	404	2,110	19.15	2.80	89.68
Hexachloro-1,3-butadiene	0.045	301	330	91.21	2.09	91.76
<i>p</i> -Dichlorobenzene	0.091	264	905	29.17	1.83	93.59
Acenaphthene	0.011	136	1,321	10.30	0.94	94.54
Nickel	0.0021	129	1,089	11.85	0.89	95.43
Fluorene	0.011	114	1,168	9.76	0.79	96.22
Propionaldehyde	0.8	91	1,744	5.22	0.63	96.85
Vinyl chloride	0.11	85	243	34.98	0.59	97.44
Manganese	0.03	61	1,090	5.60	0.42	97.86
Cadmium	0.00056	49	1,090	4.50	0.34	98.20
Fluoranthene	0.011	36	1,340	2.69	0.25	98.45
Trichloroethylene	0.2	34	308	11.04	0.24	98.69
Lead	0.015	27	1,090	2.48	0.19	98.88
Benzo(a)pyrene	0.00057	24	873	2.75	0.17	99.04
1,1,2-Trichloroethane	0.0625	22	29	75.86	0.15	99.20
Xylenes	10	22	2,132	1.03	0.15	99.35
Dichloromethane	60	17	1,791	0.95	0.12	99.47
Methyl <i>tert</i> -Butyl Ether	3.8	16	410	3.90	0.11	99.58
Hexavalent Chromium	0.000083	15	290	5.17	0.10	99.68
1,2-Dibromoethane	0.0017	14	14	100.00	0.10	99.78
Acenaphthylene	0.011	9	675	1.33	0.06	99.84
Bromomethane	0.5	8	1,404	0.57	0.06	99.90
Chloroform	9.8	4	1,478	0.27	0.03	99.92
Chloroprene	0.0021	3	3	100.00	0.02	99.94
1,1-Dichloroethane	0.625	2	30	6.67	0.01	99.96
Tetrachloroethylene	3.8	2	1,453	0.14	0.01	99.97
Bromoform	0.91	1	179	0.56	0.01	99.98
<i>cis</i> -1,3-Dichloropropene	0.25	1	6	16.67	0.01	99.99
Styrene	100	1	1,555	0.06	0.01	99.99
<i>trans</i> -1,3-Dichloropropene	0.25	1	3	33.33	0.01	100.00
Total		14,423	39,345	36.66		

The program-level pollutants of interest, as indicated by the shading in Table 4-7, are identified as follows:

- Acenaphthene
- Acetaldehyde
- Arsenic
- Benzene
- 1,3-Butadiene
- Carbon Tetrachloride
- *p*-Dichlorobenzene
- 1,2-Dichloroethane
- Ethylbenzene
- Formaldehyde
- Hexachloro-1,3-butadiene
- Naphthalene
- Nickel.

The pollutants of interest identified via the preliminary risk-based screening approach for 2013 are similar to the pollutants identified in previous years. Manganese and fluorene are the only pollutants that were program-wide pollutants of interest for 2012 but are not on the list for 2013. The risk screening value for manganese was updated resulting in a significant decrease in the number of failed screens for 2013. Fluorene is just outside the 95 percent criteria, as shown in Table 4-7, and therefore is not a pollutant of interest for 2013.

Of the 71 pollutants sampled for under the NMP that have corresponding screening values, concentrations of 38 pollutants failed at least one screen. Of these, a total of 14,423 out of 39,345 concentrations (or nearly 37 percent) failed screens. If all of the pollutants with screening values are considered (including those that did not fail any screens), the percentage of concentrations failing screens is less (14,423 of 61,337, or nearly 24 percent). Note that these percentages exclude acrolein, acetonitrile, acrylonitrile, and carbon disulfide measurements per the explanations provided in Section 3.2; these pollutants are excluded from all risk-related analyses contained in the report from this point forward.

Table 4-8 presents the total number of failed screens per site, in descending order, as a means of comparing the results of the preliminary risk-based screening process across the sites. In addition to the number of failed screens, Table 4-8 also provides the total number of screens conducted (one screen per valid preprocessed daily measurement for each site for all pollutants

with screening values). The failure rate, as a percentage, was determined from the number of failed screens and the total number of screens conducted (based on applicable measured detections) and is also provided in Table 4-8.

As shown, S4MO has the largest number of failed screens (574), followed by PXSS (554) and NBIL (510); conversely, SDGA, CHSC, and CAMS 35 failed only one or two screens each. Four additional sites did not fail any screens (STMN, HOWI, MIWI, and CAMS 85). These sites sampled only hexavalent chromium and did not sample for the entire year. The total number of screens and the number of pollutant groups measured by each site must be considered when interpreting the results in Table 4-8. For example, sites sampling four, five, or six pollutant groups tended to have a higher number of failed screens due to the large number of pollutants sampled. For sites sampling only one or two pollutant groups, it depends on the pollutant group sampled as the number of compounds analyzed varies from one (hexavalent chromium) to 80 (SNMOCs). Sites sampling only hexavalent chromium, which was detected in less than 40 percent of the valid samples collected and has a failure rate of 5 percent across the program, appear near the bottom of Table 4-8.

Table 4-8. Site-Specific Risk-Based Screening Comparison

Site	# of Failed Screens	Total # of Measured Detections ¹	% of Failed Screens	# of Pollutant Groups Analyzed
<i>S4MO</i>	574	2,687	21.36	5
<i>PXSS</i>	554	2,411	22.98	5
<i>NBIL</i>	510	2,501	20.39	6
TOOK	494	1,644	30.05	3
<i>DEMI</i>	493	1,978	24.92	4
<i>BTUT</i>	487	2,188	22.26	6
TMOK	480	1,622	29.59	3
ASKY	477	1,049	45.47	2
<i>GPCO</i>	476	1,867	25.50	4
TROK	455	1,602	28.40	3
<i>SEWA</i>	446	2,170	20.55	5
OCOK	420	1,648	25.49	3
ELNJ	404	1,187	34.04	2
<i>GLKY</i>	403	2,128	18.94	5
CSNJ	402	1,163	34.57	2

¹Total number of measured detections for all pollutants with screening values, not just those failing screens. Also excludes acrolein, acetonitrile, acrylonitrile, and carbon disulfide results.
BOLD ITALICS = EPA-designated NATTS Site

Table 4-8. Site-Specific Risk-Based Screening Comparison (Continued)

Site	# of Failed Screens	Total # of Measured Detections ¹	% of Failed Screens	# of Pollutant Groups Analyzed
SPIL	398	1,137	35.00	2
NBNJ	382	1,188	32.15	2
ROIL	372	1,090	34.13	2
CHNJ	363	1,107	32.79	2
LEKY	361	1,384	26.08	3
KMMS	334	1,175	28.43	2
ANAK	331	1,583	20.91	2
SSMS	287	959	29.93	1
TVKY	282	991	28.46	1
CKKY	281	1,464	19.19	2
ATKY	259	937	27.64	1
LAKY	257	911	28.21	1
BLKY	245	881	27.81	1
<i>UNVT</i>	226	1,733	13.04	4
ADOK	222	802	27.68	3
YUOK	203	810	25.06	3
<i>SKFL</i>	171	893	19.15	3
RICO	170	447	38.03	2
SPAZ	159	451	35.25	1
BURVT	134	483	27.74	1
<i>SYFL</i>	134	453	29.58	3
RUVT	126	441	28.57	1
ORFL	122	183	66.67	1
INDEM	121	183	66.12	1
AZFL	117	177	66.10	1
WPIN	116	174	66.67	1
<i>BOMA</i>	115	1,462	7.87	3
PACO	108	375	28.80	2
ASKY-M	104	595	17.48	1
<i>SJCA</i>	103	1,198	8.60	2
BRCO	102	377	27.06	2
<i>ROCH</i>	102	691	14.76	2
BMCO	97	357	27.17	2
<i>BXNY</i>	87	861	10.10	2
RFCO	69	239	28.87	2
<i>WADC</i>	61	694	8.79	2
<i>CELA</i>	59	679	8.69	1
<i>PRRI</i>	56	839	6.67	2
<i>RIVA</i>	56	633	8.85	2
BAKY	54	592	9.12	1
<i>RUCA</i>	54	636	8.49	1

¹Total number of measured detections for all pollutants with screening values, not just those failing screens. Also excludes acrolein, acetonitrile, acrylonitrile, and carbon disulfide results.
BOLD ITALICS = EPA-designated NATTS Site

Table 4-8. Site-Specific Risk-Based Screening Comparison (Continued)

Site	# of Failed Screens	Total # of Measured Detections ¹	% of Failed Screens	# of Pollutant Groups Analyzed
PAFL	30	300	10.00	1
LBHCA	19	315	6.03	1
WPFL	11	238	4.62	1
CAMS 35	2	25	8.00	1
CHSC	2	395	0.51	2
SDGA	1	8	12.50	1
STMN	0	8	0	1
CAMS 85	0	7	0	1
HOWI	0	4	0	1
MIWI	0	8	0	1

¹Total number of measured detections for all pollutants with screening values, not just those failing screens. Also excludes acrolein, acetonitrile, acrylonitrile, and carbon disulfide results.

BOLD ITALICS = EPA-designated NATTS Site

Although ORFL, AZFL, and INDEM have the highest failure rates (66 percent to 67 percent each), these sites sampled only one pollutant group (carbonyl compounds). Three pollutants measured with Method TO-11A (carbonyl compounds) have screening values (acetaldehyde, formaldehyde, and propionaldehyde) and two of these pollutants typically fail all or most of the screens conducted, as shown in Table 4-7. Thus, sites sampling only carbonyl compounds have relatively high failure rates. Conversely, sites that sampled several pollutant groups tended to have lower failure rates due to the larger number of HAPs screened, as is the case with S4MO, PXSS, NBIL, GLKY, BTUT, and SEWA. These sites each sampled five or six pollutant groups and have a failure rate between 19 percent and 23 percent.

The following sections from this point forward focus primarily on those pollutants designated as program-level pollutants of interest.

4.2.1 Concentrations of the Pollutants of Interest

Concentrations of the program-level pollutants of interest vary significantly, among the pollutants and among the sites. Tables 4-9 through 4-12 present the top 10 annual average concentrations and 95 percent confidence intervals by site for each of the program-level pollutants of interest (for VOC/SNMOCs, carbonyl compounds, PAHs, and metals, respectively). As described in Section 3.1, an annual average is the average concentration of all measured detections and zeros substituted for non-detects for a given year. Further, an annual average is only calculated where at least three quarterly averages could be calculated and where the site-specific method completeness is at least 85 percent. The annual average concentrations for PAHs in Table 4-11 and metals in Table 4-12 are reported in ng/m³ for ease of viewing, while annual average concentrations in Tables 4-9 and 4-10, for VOC/SNMOCs and carbonyl compounds, respectively, are reported in µg/m³. Note that not all sites sampled each pollutant group; thus, the list of possible sites presented in Tables 4-9 through 4-12 is limited to those sites sampling each pollutant. For instance, only six sites sampled TSP metals; thus, these would be the only sites to appear in Table 4-12 for each metal (TSP) pollutant of interest shown. However, two of the sites only sampled for half of the year and as a result, only four sites are listed under the TSP metals in Table 4-12.

Table 4-9. Annual Average Concentration Comparison of the VOC/SNMOC Pollutants of Interest

Rank	Benzene ($\mu\text{g}/\text{m}^3$)	1,3-Butadiene ($\mu\text{g}/\text{m}^3$)	Carbon Tetrachloride ($\mu\text{g}/\text{m}^3$)	<i>p</i> - Dichlorobenzene ($\mu\text{g}/\text{m}^3$)	1,2- Dichloroethane ($\mu\text{g}/\text{m}^3$)	Ethylbenzene ($\mu\text{g}/\text{m}^3$)	Hexachloro-1,3- Butadiene ($\mu\text{g}/\text{m}^3$)
1	PACO 1.96 \pm 0.31	TVKY 1.03 \pm 0.97	BLKY 1.11 \pm 0.77	SPAZ 0.22 \pm 0.04	TVKY 3.75 \pm 3.68	KMMS 1.95 \pm 1.08	SSMS 0.03 \pm 0.01
2	ANAK 1.56 \pm 0.34	LAKY 0.66 \pm 0.80	TVKY 0.80 \pm 0.08	<i>PXSS</i> 0.20 \pm 0.03	BLKY 1.28 \pm 0.75	ANAK 0.89 \pm 0.22	<i>S4MO</i> 0.02 \pm 0.01
3	RICO 1.52 \pm 0.26	BLKY 0.63 \pm 0.49	<i>SEWA</i> 0.69 \pm 0.03	TMOK 0.10 \pm 0.02	LAKY 0.70 \pm 0.45	SPAZ 0.68 \pm 0.15	NBNJ 0.02 \pm 0.01
4	ASKY 1.52 \pm 1.39	CCKY 0.26 \pm 0.40	LAKY 0.68 \pm 0.03	<i>S4MO</i> 0.09 \pm 0.02	ATKY 0.30 \pm 0.10	<i>PXSS</i> 0.67 \pm 0.11	OCOK 0.02 \pm 0.01
5	BMCO 1.26 \pm 0.19	SPAZ 0.22 \pm 0.07	CCKY 0.67 \pm 0.02	SSMS 0.08 \pm 0.02	CCKY 0.24 \pm 0.08	<i>BTUT</i> 0.49 \pm 0.24	CSNJ 0.02 \pm 0.01
6	TOOK 1.21 \pm 0.17	<i>PXSS</i> 0.21 \pm 0.05	<i>DEMI</i> 0.67 \pm 0.02	BURVT 0.06 \pm 0.01	<i>BTUT</i> 0.11 \pm 0.03	<i>GPCO</i> 0.49 \pm 0.07	CHNJ 0.02 \pm 0.01
7	BRCO 1.14 \pm 0.20	<i>GPCO</i> 0.15 \pm 0.03	ATKY 0.67 \pm 0.02	KMMS 0.05 \pm 0.01	CSNJ 0.09 \pm 0.01	TOOK 0.45 \pm 0.06	ROIL 0.02 \pm 0.01
8	SPAZ 1.07 \pm 0.21	ANAK 0.15 \pm 0.04	<i>GLKY</i> 0.67 \pm 0.03	ANAK 0.05 \pm 0.01	<i>S4MO</i> 0.09 \pm 0.01	TMOK 0.43 \pm 0.07	LAKY 0.02 \pm 0.01
9	TVKY 1.06 \pm 0.32	SPIL 0.13 \pm 0.02	KMMS 0.66 \pm 0.02	OCOK 0.05 \pm 0.01	NBNJ 0.09 \pm 0.01	ELNJ 0.43 \pm 0.06	BLKY 0.02 \pm 0.01
10	<i>PXSS</i> 1.06 \pm 0.18	ELNJ 0.11 \pm 0.01	SSMS 0.66 \pm 0.02	<i>BTUT</i> 0.05 \pm 0.03	BURVT 0.08 \pm 0.01	TROK 0.39 \pm 0.06	TMOK 0.02 \pm 0.01

BOLD ITALICS = EPA-designated NATTS Site

Table 4-10. Annual Average Concentration Comparison of the Carbonyl Compound Pollutants of Interest

Rank	Acetaldehyde ($\mu\text{g}/\text{m}^3$)	Formaldehyde ($\mu\text{g}/\text{m}^3$)
1	<i>BTUT</i> 4.18 \pm 0.36	<i>BTUT</i> 8.05 \pm 0.87
2	<i>GPCO</i> 3.79 \pm 0.57	<i>GPCO</i> 6.44 \pm 1.22
3	CSNJ 2.78 \pm 0.33	CSNJ 4.96 \pm 0.59
4	<i>PXSS</i> 2.78 \pm 0.29	ELNJ 4.90 \pm 0.67
5	ELNJ 2.60 \pm 0.26	<i>PXSS</i> 3.89 \pm 0.22
6	SPIL 2.37 \pm 0.55	WPIN 3.41 \pm 0.37
7	<i>NBIL</i> 2.37 \pm 0.31	SPIL 3.31 \pm 0.49
8	TOOK 2.02 \pm 0.25	<i>S4MO</i> 3.23 \pm 0.55
9	<i>S4MO</i> 1.98 \pm 0.22	TMOK 3.19 \pm 0.45
10	TMOK 1.94 \pm 0.25	ROIL 3.19 \pm 0.57

BOLD ITALICS = EPA-designated NATTS Site

Table 4-11. Annual Average Concentration Comparison of the PAH Pollutants of Interest

Rank	Acenaphthene (ng/m^3)	Naphthalene (ng/m^3)
1	<i>NBIL</i> 25.12 \pm 8.19	<i>NBIL</i> 155.94 \pm 44.27
2	<i>ROCH</i> 19.37 \pm 5.35	<i>GPCO</i> 136.93 \pm 23.05
3	<i>DEMI</i> 9.62 \pm 2.72	<i>BXNY</i> 126.77 \pm 12.63
4	<i>GPCO</i> 8.05 \pm 1.77	<i>CELA</i> 111.44 \pm 15.95
5	<i>BXNY</i> 6.46 \pm 1.15	<i>DEMI</i> 104.57 \pm 14.63
6	<i>S4MO</i> 5.02 \pm 1.16	<i>SJJCA</i> 93.97 \pm 22.27
7	WPFL 4.62 \pm 2.72	<i>PXSS</i> 93.36 \pm 18.63
8	<i>CELA</i> 4.26 \pm 0.54	<i>RIVA</i> 86.87 \pm 13.95
9	<i>SEWA</i> 3.68 \pm 1.10	<i>WADC</i> 83.14 \pm 13.50
10	<i>RIVA</i> 3.45 \pm 0.66	<i>RUCA</i> 81.40 \pm 16.05

BOLD ITALICS = EPA-designated NATTS Site

Table 4-12. Annual Average Concentration Comparison of the Metals Pollutants of Interest

Rank	Arsenic (PM ₁₀) (ng/m ³)	Arsenic (TSP) (ng/m ³)	Nickel (PM ₁₀) (ng/m ³)	Nickel (TSP) (ng/m ³)
1	ASKY-M 1.24 ± 0.29	TROK 0.80 ± 0.11	ASKY-M 2.40 ± 0.89	TOOK 2.09 ± 0.42
2	<i>BTUT</i> 0.99 ± 0.40	TOOK 0.78 ± 0.07	<i>SEWA</i> 1.78 ± 0.44	TROK 1.43 ± 0.24
3	BAKY 0.82 ± 0.22	TMOK 0.65 ± 0.07	<i>PXSS</i> 1.49 ± 0.21	TMOK 1.30 ± 0.20
4	<i>SEWA</i> 0.79 ± 0.13	OCOK 0.46 ± 0.06	<i>BTUT</i> 1.44 ± 0.24	OCOK 0.84 ± 0.12
5	<i>S4MO</i> 0.73 ± 0.08		<i>BOMA</i> 1.42 ± 0.23	
6	PAFL 0.72 ± 0.22		<i>SJJCA</i> 1.40 ± 0.21	
7	LEKY 0.68 ± 0.12		<i>S4MO</i> 1.06 ± 0.26	
8	<i>NBIL</i> 0.62 ± 0.11		PAFL 0.76 ± 0.10	
9	CCKY 0.61 ± 0.15		<i>NBIL</i> 0.75 ± 0.07	
10	<i>SJJCA</i> 0.52 ± 0.13		BAKY 0.61 ± 0.15	

BOLD ITALICS = EPA-designated NATTS Site

Observations from Tables 4-9 through 4-12 include the following:

- The highest annual average concentration among the program-wide pollutants of interest was calculated for formaldehyde for BTUT ($8.05 \pm 0.87 \mu\text{g}/\text{m}^3$). This was also true for BTUT in 2012, although the concentration for 2013 is twice as high as it was for 2012. Formaldehyde and acetaldehyde together account for 18 of the 19 annual average concentrations greater than $2.0 \mu\text{g}/\text{m}^3$ shown in Tables 4-9 through 4-12 (the one exception being for TVKY's annual average concentration of 1,2-dichloroethane).
- All 10 annual average concentrations of benzene shown in Table 4-9 are greater than $1 \mu\text{g}/\text{m}^3$, the only pollutant for which this is true. PACO has the highest annual average benzene concentration ($1.96 \pm 0.31 \mu\text{g}/\text{m}^3$) among sites sampling benzene, with four of the five Garfield County, Colorado sites ranking among the 10 highest. Only RFCO does not appear in Table 4-9, with this site's annual average benzene concentration ranking among the lowest ($0.57 \pm 0.12 \mu\text{g}/\text{m}^3$). Other sites ranking among the highest benzene concentrations include ANAK, ASKY, TOOK, TVKY, and the two Phoenix sites (SPAZ and PXSS). Note that the confidence intervals for these sites span a relatively small range, with one exception. The annual average concentration for ASKY is $1.52 \pm 1.39 \mu\text{g}/\text{m}^3$. The large confidence interval for this site indicates that this annual average is likely influenced by outlier(s) as opposed to running on the higher side on a regular basis. The highest benzene concentration measured across the program was measured at ASKY on November 6, 2013

(43.5 $\mu\text{g}/\text{m}^3$). The next highest benzene concentration measured across the program was considerably less (9.38 $\mu\text{g}/\text{m}^3$), which was measured at OCOK on the same date.

- The four highest annual average concentrations of 1,3-butadiene were calculated for Calvert City, Kentucky sites. The annual averages vary significantly by site, ranging from $1.03 \pm 0.97 \mu\text{g}/\text{m}^3$ for TVKY to $0.26 \pm 0.40 \mu\text{g}/\text{m}^3$ for CCKY. The annual 1,3-butadiene average for the fifth Calvert City site (ATKY) is considerably less and does not appear in Table 4-9. Note, however, the large confidence intervals associated with each of the annual average concentrations for the Calvert City sites, indicating a considerable amount of variability in the measurements. Concentrations of 1,3-butadiene measured at these four sites account for all 19 1,3-butadiene concentrations greater than 1 $\mu\text{g}/\text{m}^3$ measured across the program.
- Calvert City sites also account for five of the 10 highest annual average concentrations of carbon tetrachloride. Most of the annual average concentrations of carbon tetrachloride do not vary significantly across the sites; less than 0.15 $\mu\text{g}/\text{m}^3$ separates most of the annual average carbon tetrachloride concentrations. However, this is not true for BLKY or TVKY. BLKY has the highest annual average concentration of carbon tetrachloride across the sites by a large margin ($1.12 \pm 0.77 \mu\text{g}/\text{m}^3$). The highest concentration of carbon tetrachloride across the program was measured at BLKY (23.7 $\mu\text{g}/\text{m}^3$) and is an order of magnitude higher than the next highest measurement, which was measured at TVKY (2.33 $\mu\text{g}/\text{m}^3$). These two sites account for 11 of the 14 carbon tetrachloride concentrations greater than 1 $\mu\text{g}/\text{m}^3$ measured across the program (the other three were measured at LAKY, SEWA, and SSMS).
- The five Calvert City sites also account for the five highest annual average concentrations of 1,2-dichloroethane, although the concentrations vary significantly. Note the large confidence interval for the annual average for TVKY ($3.75 \pm 3.68 \mu\text{g}/\text{m}^3$); the highest 1,2-dichloroethane concentration across the program was measured at this site (111 $\mu\text{g}/\text{m}^3$). Although the second highest 1,2-dichloroethane concentration was also measured at TVKY, it was significantly less (19.3 $\mu\text{g}/\text{m}^3$). These five sites account for all but one of the 77 measurements of 1,2-dichloroethane greater than 0.5 $\mu\text{g}/\text{m}^3$ (the one exception was measured at BTUT, which ranks sixth in Table 4-9 for 1,2-dichloroethane).
- The highest annual average concentration of ethylbenzene ($1.95 \pm 1.08 \mu\text{g}/\text{m}^3$, calculated for KMMS) is more than twice the next highest annual average concentration of this pollutant ($0.89 \pm 0.22 \mu\text{g}/\text{m}^3$, calculated for ANAK). Nine of the 10 ethylbenzene concentrations greater than 5 $\mu\text{g}/\text{m}^3$ across the program were measured at KMMS (with the one additional concentration measured at BTUT).
- Hexachloro-1,3-butadiene and *p*-dichlorobenzene are the only two VOCs in Table 4-9 that do not have at least one annual average concentration greater than 1 $\mu\text{g}/\text{m}^3$. The annual average concentrations of *p*-dichlorobenzene calculated for the two Phoenix sites are significantly higher than the remaining annual averages shown for this pollutant, although the range of annual average concentrations shown is less than

- 0.18 $\mu\text{g}/\text{m}^3$. The range of annual average concentrations for hexachloro-1,3-butadiene is even less, varying by less than 0.01 $\mu\text{g}/\text{m}^3$ across the sites shown.
- ANAK, PXSS, SPAZ, LAKY, BLKY, and TVKY each appear in Table 4-9 a total of four times.
 - The sites with the three highest annual average concentrations of acetaldehyde shown in Table 4-10 are also the same three sites with the highest annual average concentrations of formaldehyde (BTUT, GPCO, and CSNJ). Although their order varies somewhat, most of the sites that appear for acetaldehyde also appear for formaldehyde.
 - The maximum acetaldehyde concentration was measured at SPIL (14.2 $\mu\text{g}/\text{m}^3$), which ranks sixth for its annual average concentration. The next five highest acetaldehyde concentrations (ranging from 7.53 $\mu\text{g}/\text{m}^3$ to 10.7 $\mu\text{g}/\text{m}^3$) were measured at GPCO on consecutive sample days between June 9, 2013 and July 3, 2013. Acetaldehyde concentrations measured at SPIL, GPCO, and BTUT account for all 11 acetaldehyde measurements greater than 7 $\mu\text{g}/\text{m}^3$ measured across the program.
 - As shown in Table 4-10, four sites have annual average formaldehyde concentrations greater than 4 $\mu\text{g}/\text{m}^3$ (BTUT, GPCO, CSNJ, and ELNJ) and all 10 sites shown in Table 4-10 have annual average concentrations of formaldehyde greater than 3 $\mu\text{g}/\text{m}^3$.
 - Although BTUT has the highest annual average concentration of formaldehyde ($8.05 \pm 0.87 \mu\text{g}/\text{m}^3$), the five highest concentrations measured across the program were measured at GPCO. Of the eight formaldehyde concentrations greater than 15 $\mu\text{g}/\text{m}^3$ measured across the program, all but one was measured at GPCO (with the other one measured at ELNJ). The variability in GPCO's measurements of formaldehyde is indicated by the confidence interval shown in Table 4-10. Formaldehyde concentrations measured at GPCO range from 1.97 $\mu\text{g}/\text{m}^3$ to 21.9 $\mu\text{g}/\text{m}^3$, with a median concentration of 4.80 $\mu\text{g}/\text{m}^3$.
 - Table 4-11 shows that NBIL has the highest annual average concentration for each of the program-wide PAH pollutants of interest (acenaphthene and naphthalene). For acenaphthene, the annual average concentrations for NBIL and ROCH are considerably higher than the next highest annual averages and have relatively large confidence intervals associated with them. Together, these two sites account for the 26 highest acenaphthene concentrations measured across the program. DEMI and KMMS are the only other sites for which acenaphthene concentrations greater than 40 ng/m^3 were measured across the program. DEMI ranked third for its annual average concentration of acenaphthene but KMMS did not sample long enough for annual averages to be calculated. The confidence interval calculated for WPFL is relatively large compared to its annual average concentration ($4.62 \pm 2.72 \text{ ng}/\text{m}^3$); concentrations measured at this site range from 0.665 ng/m^3 to 39.9 ng/m^3 .
 - Naphthalene concentrations measured at NBIL account for three of the four measurements greater than 500 ng/m^3 measured across the program (with the other measured at WPFL, whose annual average ranks 19th and therefore does not appear

in Table 4-11). Another eight concentrations measured at NBIL were greater than 300 ng/m³. Other sites that measured naphthalene concentrations greater than 300 ng/m³ include GPCO (4), SJJCA (3), SKFL (1), DEMI (1), CELA (1), RIVA (1), RUCA (1). All of these sites, with the exception of SKFL, appear in Table 4-11.

- ASKY-M has the highest annual average concentration for both of the program-wide PM₁₀ metals pollutants of interest. Four of the five Kentucky sites sampling PM₁₀ metals appear in Table 4-12 for arsenic while only two appear in Table 4-12 for nickel. BTUT, SEWA, and S4MO round out the top five for arsenic. Annual averages of arsenic for S4MO consistently rank among the highest in past annual reports. Aside from ASKY-M, NATTS sites have the highest ranking annual averages for nickel. For the last several years, the annual average nickel concentration for SEWA has been at or near the top.
- Although ASKY-M's annual arsenic concentration is the highest among NMP sites sampling PM₁₀ metals (1.24 ± 0.29 ng/m³), the maximum arsenic concentration was measured at BTUT (9.18 ng/m³). Arsenic concentrations greater than 3 ng/m³ were measured at both BTUT and ASKY-M (four each). Compared to other sites, ASKY-M has the greatest number of arsenic concentrations greater than 1 ng/m³ (26), followed by BAKY (18), SEWA (14), and S4MO (13), with BTUT, NBIL, TROK, and LEKY each measuring 10.
- Among the Oklahoma sites sampling TSP metals, TROK has the highest annual average concentration of arsenic (0.80 ± 0.11 ng/m³), although the annual average concentration for TOOK is similar (0.78 ± 0.07 ng/m³). The other Tulsa site, TMOK, ranks third while the OCOK site has a significantly lower annual average concentration of arsenic (0.46 ± 0.06 ng/m³). ADOK and YUOK are not shown in Table 4-12 because these sites did not sample long enough for annual averages to be calculated.
- The two highest nickel concentrations program-wide were measured at ASKY-M (21.2 ng/m³ and 17.1 ng/m³). The third highest concentration measured at this site is considerably less (5.49 ng/m³) and the median nickel concentration for this site is 1.46 ng/m³, nearly 1 ng/m³ less than the annual average. This site has the largest confidence interval associated with its annual average, although the confidence interval for SEWA is also higher than the confidence intervals calculated for other sites. Nickel concentrations measured at SEWA range from 0.17 ng/m³ to 9.75 ng/m³, with a median concentration of 1.25 ng/m³.
- Among the Oklahoma sites sampling TSP metals, the Tulsa sites ranked highest for nickel while the Oklahoma City site has a significantly lower annual average concentration of nickel. Nickel concentrations measured at TOOK range from 0.687 ng/m³ to 10.98 ng/m³, with a median concentration of 1.58 ng/m³. Nickel concentrations measured at the other Oklahoma sites were less variable.
- S4MO and PXSS appear on the top 10 list for eight of the 13 program-level pollutants of interest shown in Tables 4-9 through 4-12; BTUT and TMOK appear in these tables for seven of the 13 program-level pollutants of interest; and GPCO appears in

the tables for six of the 13 program-level pollutants of interest. TOOK and NBIL each appear in Tables 4-9 through 4-12 a total of five times.

4.3 The Contribution from Mobile Sources

Ambient air is significantly affected by mobile sources, as discussed in Section 3.3.1. Table 4-13 contains several parameters that are used to assess if mobile sources are affecting air quality near the monitoring sites, including emissions data from the NEI, concentration data, and site-characterizing data, such as vehicle ownership.

4.3.1 Mobile Source Emissions

Emissions from mobile sources contribute significantly to air pollution in the United States. Mobile source emissions can be broken into two categories: onroad and nonroad. Onroad emissions come from mobile sources such as automobiles, motorcycles, buses, and trucks that use roadways; nonroad emissions come from the remaining mobile sources such as locomotives, lawn mowers, airplanes, and boats (EPA, 2011b). Table 4-13 contains county-level onroad and nonroad HAP emissions from the 2011 NEI, version 2. Total mobile source emissions for each county are presented in Table 2-2.

Mobile source emissions tend to be highest in large urban areas and lowest in rural areas. Estimated onroad county emissions were highest in Los Angeles County, California (where CELA and LBHCA are located), followed by Harris County, Texas (where CAMS 35 is located), Maricopa County, Arizona (where PXSS and SPAZ are located), and Cook County, Illinois (where NBIL and SPIL are located). Estimated onroad emissions were lowest in five of the six counties in Kentucky (the exception being Fayette County, where LEKY is located), Rutland County, Vermont (RUVT), and Chesterfield County, South Carolina (CHSC). Estimated nonroad county emissions were also highest in Los Angeles County, California; Cook County, Illinois; and Maricopa County, Arizona. Estimated nonroad county emissions were lowest in Carter County, Kentucky (GLKY); Boyd County, Kentucky (where ASKY and ASKY-M are located); Canadian County, Oklahoma (where YUOK is located), and Chesterfield County, South Carolina.

Table 4-13. Summary of Mobile Source Information by Monitoring Site

Site	County-level Motor Vehicle Registration ¹ (# of Vehicles)	Annual Average Daily Traffic ¹ (# of Vehicles)	County-level Daily VMT ¹	County-Level Onroad HAP Emissions ² (tpy)	County-Level Nonroad HAP Emissions ^{2,3} (tpy)	Hydrocarbon Average ⁴ (ppbv)
ADOK	835,642	34,700	27,469,678	2,722.16	703.01	1.33
ANAK	358,999	20,193	5,301,813	895.95	1,853.36	5.92
ASKY	39,196	7,230	1,256,000	147.73	24.80	2.30
ASKY-M	39,196	12,842	1,256,000	147.73	24.80	NA
ATKY	30,254	3,262	1,241,000	124.82	351.54	3.98
AZFL	879,683	42,500	21,460,593	2,324.65	892.83	NA
BAKY	38,811	922	1,366,000	162.96	105.44	NA
BLKY	8,338	2,510	391,000	52.95	83.12	3.09
BMCO	74,036	1,880	2,171,019	249.78	77.83	NA
BOMA	393,252	27,654	10,963,634	594.94	420.78	NA
BRCO	74,036	1,182	2,171,019	249.78	77.83	NA
BTUT	274,716	130,950	6,950,795	669.34	261.40	4.86
BURVT	172,203	14,200	4,051,781	281.01	196.55	1.84
BXNY	254,752	98,899	8,170,256	596.68	243.71	NA
CAMS 35	3,401,957	31,043	56,245,209	6,834.27	1,809.32	NA
CAMS 85	72,689	1,250	2,511,619	245.30	101.13	NA
CCKY	30,254	4,050	1,241,000	124.82	351.54	2.55
CELA	7,609,517	231,000	214,482,440	10,307.83	4,465.47	NA
CHNJ	443,969	11,215	14,622,523	742.15	536.31	1.41
CHSC	41,728	700	1,265,439	149.54	57.28	NA
CSNJ	458,294	3,231	10,753,157	657.47	296.19	3.57
DEMI	1,335,516	94,600	41,554,962	3,483.29	1,080.06	3.24
ELNJ	485,427	250,000	12,081,401	678.06	339.40	3.91
GLKY	25,487	303	1,076,000	133.76	11.48	0.96
GPCO	176,969	11,000	3,355,813	511.27	153.45	3.99
HOWI	99,078	5,100	2,568,234	278.27	180.19	NA
INDEM	425,854	34,754	15,741,000	1,074.29	533.04	NA
KMMS	54,826	9,900	1,961,288	197.97	62.31	5.15
LAKY	30,254	1,189	1,241,000	124.82	351.54	3.69
LBHCA	7,609,517	285,000	214,482,440	10,307.83	4,465.47	NA
LEKY	208,983	10,083	7,490,000	773.37	342.67	1.84
MIWI	641,582	12,400	16,098,216	1,458.78	507.53	NA
NBIL	2,074,419	115,700	87,972,644	5,113.62	3,768.84	1.49
NBNJ	734,425	110,653	21,634,307	1,048.39	528.78	1.97
OCOK	835,642	41,500	27,469,678	2,722.16	703.01	1.73
ORFL	1,181,540	29,500	34,904,854	2,838.52	1,282.94	NA
PACO	74,036	15,000	2,171,019	249.78	77.83	NA
PAFL	1,181,540	49,000	34,904,854	2,838.52	1,282.94	NA
PRRI	511,015	136,800	11,670,714	1,043.74	306.55	NA

¹Individual references provided in each state section.

²Reference: 2011 NEI Version 2 (EPA, 2015a)

³Nonroad Emissions include Nonroad data as well as emissions from SCCs that were traditionally mobile categories, such as aircraft, but have been included in Point or Nonpoint inventories in the 2011 NEI.

⁴This parameter is only available for monitoring sites sampling VOCs and is not limited by the annual average criteria.

BOLD ITALICS = EPA-designated NATTS Site

NA = VOC samples were not collected at this monitoring site.

Table 4-13. Summary of Mobile Source Information by Monitoring Site (Continued)

Site	County-level Motor Vehicle Registration ¹ (# of Vehicles)	Annual Average Daily Traffic ¹ (# of Vehicles)	County-level Daily VMT ¹	County-Level Onroad HAP Emissions ² (tpy)	County-Level Nonroad HAP Emissions ^{2,3} (tpy)	Hydrocarbon Average ⁴ (ppbv)
PXSS	3,761,859	29,515	90,393,000	6,701.23	3,214.61	4.25
RFCO	74,036	16,000	2,171,019	249.78	77.83	NA
RICO	74,036	15,000	2,171,019	249.78	77.83	NA
RIVA	350,000	72,000	8,366,945	580.70	165.67	NA
ROCH	558,063	85,162	15,963,343	1,153.83	588.44	NA
ROIL	267,302	7,750	7,911,443	591.93	223.15	2.26
RUCA	1,788,322	150,000	55,336,730	2,271.03	973.29	NA
RUVT	79,795	10,400	1,736,164	116.35	128.97	2.40
SAMO	1,117,375	100,179	24,065,245	449.19	161.90	1.89
SDGA	479,533	138,470	20,900,748	1,539.38	275.40	NA
SEWA	1,791,383	176,000	23,266,320	4,541.86	2,348.31	1.87
SJCA	1,575,973	115,000	41,478,310	2,984.29	650.57	NA
SKFL	879,683	47,500	21,460,593	2,324.65	892.83	NA
SPAZ	3,761,859	25,952	90,393,000	6,701.23	3,214.61	4.43
SPIL	2,074,419	186,100	87,972,644	5,113.62	3,768.84	2.42
SSMS	54,826	19,000	1,961,288	197.97	62.31	2.22
STMN	221,636	24,100	5,078,055	618.57	657.39	NA
SYFL	1,157,057	10,000	34,614,572	3,166.81	1,093.34	NA
TMOK	614,543	12,500	20,453,745	3,416.21	733.68	2.86
TOOK	614,543	64,424	20,453,745	3,416.21	733.68	3.29
TROK	614,543	56,200	20,453,745	3,416.21	733.68	3.13
TVKY	30,254	2,230	1,241,000	124.82	351.54	8.90
UNVT	172,203	1,100	4,051,781	281.01	196.55	0.70
WADC	322,350	8,700	9,786,301	580.26	249.51	NA
WPFL	1,159,114	6,600	33,617,131	3,051.13	2,146.53	NA
WPIN	830,851	143,970	31,727,000	3,351.30	691.35	NA
YUOK	106,000	45,400	4,457,374	395.05	52.52	1.24

¹Individual references provided in each state section.

²Reference: 2011 NEI Version 2 (EPA, 2015a)

³Nonroad Emissions include Nonroad data as well as emissions from SCCs that were traditionally mobile categories, such as aircraft, but have been included in Point or Nonpoint inventories in the 2011 NEI.

⁴This parameter is only available for monitoring sites sampling VOCs and is not limited by the annual average criteria.

BOLD ITALICS = EPA-designated NATTS Site

NA = VOC samples were not collected at this monitoring site.

4.3.2 Hydrocarbon Concentrations

Hydrocarbons are organic compounds that contain only carbon and hydrogen.

Hydrocarbons are derived primarily from crude petroleum sources and are classified according to their arrangement of atoms as alicyclic, aliphatic, and aromatic. Hydrocarbons are of prime economic importance because they encompass the constituents of the major fossil fuels, petroleum and natural gas, as well as plastics, waxes, and oils. Hydrocarbons in the atmosphere

originate from natural sources and from various anthropogenic sources, such as the combustion of fuel and biomass, petroleum refining, petrochemical manufacturing, solvent use, and gas and oil production and use. In urban air pollution, these components, along with oxides of nitrogen (NO_x) and sunlight, contribute to the formation of tropospheric ozone. Thus, the concentration of hydrocarbons in ambient air may act as an indicator of mobile source activity levels. Several hydrocarbons are sampled with Method TO-15, including benzene, ethylbenzene, and toluene.

Table 4-13 presents the average of the sum of hydrocarbon concentrations for each site sampling VOCs. Note that only sites sampling VOCs have data in this column. Table 4-13 shows that TVKY, ANAK, KMMS, BTUT, and SPAZ have the highest hydrocarbon averages among the sites sampling VOCs. Interestingly, several of these sites are not the typical sites in past reports. TVKY was among the higher sites in the 2012 report and is located in a highly industrialized area in a moderately populated area. ANAK is a new site for 2013. ANAK is a site with past participation in the NMP (2009) and had relatively high hydrocarbon concentrations then, with the highest hydrocarbon average for that year. This site is located in Anchorage, the most populous city in Alaska. KMMS, a new site in the NMP for 2013, is a source-oriented site but is located in a moderately populated area. BTUT has higher concentrations compared to previous years, and now ranks among the top five highest hydrocarbon averages. BTUT is located in a suburb just north of the Salt Lake City area, less than one-half mile from I-15. SPAZ tends to have relatively high hydrocarbon concentrations, based on past reports, and is located in a highly urbanized area (Phoenix), but not near a major roadway.

In past reports, TOOK and ELNJ have been among the sites with the highest hydrocarbon averages. These sites are located in highly populated urban areas and in relatively close proximity to heavily traveled roadways. TOOK is located near Exit 3A of I-244 in Tulsa, Oklahoma while ELNJ is location on Exit 13A of the New Jersey Turnpike. Both sites are also located in close proximity to industry. Both of these sites exhibit a relatively substantial decrease in their average hydrocarbon concentration from 2012 to 2013.

The sites with the lowest hydrocarbon averages are UNVT, GLKY, YUOK, and ADOK. UNVT and GLKY are located in rural areas. Both YUOK and ADOK are located on the periphery of a large urban area (Oklahoma City) and near major freeways.

The average sum of hydrocarbon concentrations can be compared to other indicators of mobile source activity to determine if correlations exist. Pearson correlation coefficients were calculated between the average sum of hydrocarbon concentrations and the onroad (-0.01) and nonroad (0.06) emissions. The Pearson correlation coefficients indicate virtually no correlation between the emissions and the average hydrocarbon concentrations.

4.3.3 Motor Vehicle Ownership

Another indicator of motor vehicle activity near the monitoring sites is the total number of vehicles owned by residents in the county where each monitoring site is located, which includes passenger vehicles, trucks, and commercial vehicles, as well as vehicles that can be regional in use such as boats or snowmobiles. Actual county-level vehicle registration data were obtained from each applicable state or local agency, where possible. If data were not available, vehicle registration data are available at the state-level (FHWA, 2014). The county proportion of the state population was then applied to the state registration count.

The county-level motor vehicle ownership data and the average summed hydrocarbon concentrations are presented in Table 4-13. As previously discussed, TVKY, ANAK, KMMS, BTUT, and SPAZ have the highest average summed hydrocarbon concentrations, respectively, while UNVT, GLKY, YUOK, and ADOK have the lowest. Table 4-13 also shows that SPAZ, PXSS, NBIL, and SPIL have the highest county-level vehicle ownership of the sites sampling VOCs, while the Kentucky sites located in Livingston, Carter, and Marshall Counties have the lowest. The Pearson correlation coefficient calculated between these two datasets is 0.03, a weak correlation. CELA and LBHCA, which have the highest county-level vehicle ownership of all NMP sites, did not sample VOCs under the NMP; this is also true for many of the sites with larger vehicle ownership counts.

The vehicle ownership at the county-level may not be completely indicative of the ownership in a particular area. As an illustration, for a county with a large city in the middle of its boundaries and less populated areas surrounding it, the total county-level ownership may be more representative of areas inside the city limits than in the rural outskirts.

Other factors may affect the reliability of motor vehicle ownership data as an indicator of ambient air monitoring data results:

- Estimates of higher vehicle ownership surrounding a monitoring site do not necessarily imply increased motor vehicle use in the immediate vicinity of a monitoring site. Conversely, sparsely populated regions often contain heavily traveled roadways.
- Emissions sources in the area other than motor vehicles may significantly affect levels of hydrocarbons in ambient air.

4.3.4 Estimated Traffic Volume

Traffic data for each of the participating monitoring sites were obtained from state and local agencies, primarily departments of transportation. Most of the traffic counts in this report reflect AADT, which is the “annual traffic count divided by the number of days in the year,” and incorporates both directions of traffic (FHWA, 2013a). AADT counts obtained were based on data from 2004 to 2013, primarily 2011 forward. The updated traffic counts are presented in Table 4-13. The traffic data presented in Table 4-13 represent the most recently available data applicable to the monitoring sites.

There are several limitations to obtaining the AADT near each monitoring site. AADT statistics are developed for roadways, such as interstates, state highways, or local roadways, which are managed by different municipalities or government agencies. AADT is not always available for rural areas or for secondary roadways. For monitoring sites located near interstates, the AADT for the interstate segment closest to the site was obtained. For other monitoring sites, the highway or secondary road closest to the monitoring site was used. Only one AADT value was obtained for each monitoring site. The intersection or roadway chosen for each monitoring site is discussed in each individual state section (Sections 5 through 30).

For all monitoring sites (not just those sampling VOCs), the highest daily traffic volume occurs near LBHCA, ELNJ, CELA, and SPIL. LBHCA is near I-405 east of the intersection with I-710; ELNJ is located near Exit 13A on I-95; CELA is located in downtown Los Angeles; and SPIL is located near the Chicago-O’Hare International Airport, just west of I-294. Of these, only ELNJ and SPIL sampled VOCs. ELNJ has the second highest traffic volume but the ninth

highest hydrocarbon average; SPIL has the fourth highest traffic volume but the 18th highest hydrocarbon average.

Of the sites sampling VOCs, ELNJ, SPIL, SEWA, and BTUT have the highest daily traffic volumes while GLKY, UNVT, and LAKY have the lowest, as shown in Table 4-13. A Pearson correlation coefficient calculated between the average summed hydrocarbon calculations and the traffic counts is -0.06, which is a weak correlation.

4.3.5 Vehicle Miles Traveled

Another approach to determine how mobile sources affect urban air quality is to review VMT. VMT is “the mileage traveled by all vehicles on a road system over a period of time such as a year” (FHWA, 2013a). Thus, VMT values tend to be large (in the millions). County-level VMT was obtained for each of the participating monitoring sites from state organizations, primarily departments of transportation. However, these data are not readily available for all states. In addition, not all states provide this information on the same level. For example, many states provide VMT for all public roads, while the state of Colorado provides this information for state highways only. County-level VMT are presented in Table 4-13, where available. In the absence of suitable VMT data, county-level VMT was obtained from the NEI (EPA, 2015a).

Of the sites sampling VOCs, county-level VMT was highest for PXSS and SPAZ, SPIL and NBIL, and DEMI (Wayne County, Michigan). SPAZ and PXSS rank fifth and sixth, respectively, for the average summed hydrocarbon concentration, SPIL and NBIL rank 18th and 29th, and DEMI ranks 13th, among the sites with the highest county-level VMT. The sites with the lowest county-level VMT are BLKY, GLKY, and the sites in Marshall County, Kentucky. TVKY, which is located in Marshall County, Kentucky ranks highest for its average summed hydrocarbon concentration. A Pearson correlation coefficient calculated between the average summed hydrocarbon concentrations and VMT is -0.04, indicating little correlation between hydrocarbon concentrations and county-level VMT. It is important to note that many of the sites with larger VMT did not measure VOCs under the NMP (such as CELA, LBHCA, CAMS 35, RUCA, and SJCA).

4.4 Variability Analysis

This section presents the results of the two variability analyses described in Section 3.3.2.

4.4.1 Inter-site Variability

Figures 4-1 through 4-13 are bar graphs depicting the site-specific annual averages (in gray) overlain on the program-level averages (indicated by the solid shading), as presented in Section 4.1. For each program-level pollutant of interest, the inter-site variability graphs allow the reader to see how the individual site-specific annual averages feed into the program-level averages (i.e., if a specific site(s) is driving the program average). In addition, the confidence intervals provided on the inter-site variability graphs are an indication of the amount of variability contained within the site-specific dataset and thus, annual averages. The published MDL from the ERG laboratory is also plotted on the graph as an indication of how the data fall in relation to the MDL.

Several items to note about these figures: Some sites do not have annual averages presented on the inter-site variability graphs because they did not meet the criteria specified in Section 3.1. For the sites sampling metals, the program-level average for sites collecting PM₁₀ samples is presented in green while the program-level average for sites collecting TSP samples is presented in pink. For benzene, 1,3-butadiene, and ethylbenzene, the three pollutants sampled and analyzed by two methods (VOC and SNMOC) and identified as program-level pollutants of interest, two graphs are presented, one for each method. Note, however, that the Garfield County sites have their canister samples analyzed using the SNMOC method only while BTUT and NBIL have their canister samples analyzed using both methods, but only the VOCs results are discussed throughout the remainder of this report, as described in Section 3.2.

Observations from Figures 4-1 through 4-13 include the following:

- The program-level average concentration of acenaphthene is 4.89 ng/m³, as shown in orange in Figure 4-1. Site-specific annual average concentrations range from 0.30 ng/m³ (UNVT) to 25.12 ng/m³ (NBIL). The annual average concentrations for ROCH and NBIL are three and four times greater than the program-level average for acenaphthene, respectively, and have the most variability associated with the measurements, as indicated by the large confidence intervals. Other sites with annual average concentrations greater than the program-level average include DEMI, GPCO and BXNY. Sites with relatively low annual average concentrations (less than

1 ng/m³) other than UNVT include GLKY and CHSC. Annual averages could not be calculated for LBHCA and SYFL.

- The program-level average concentration of acetaldehyde is 1.80 µg/m³, as shown in purple in Figure 4-2. Site-specific annual average concentrations range from 0.46 µg/m³ (BMCO) to 4.18 µg/m³ (BTUT). The annual average concentrations for BTUT and GPCO are twice the program-level average for acetaldehyde. GPCO and SPIL have the most variability associated with their measurements, as indicated by the confidence intervals shown. Other sites with annual average concentrations greater than the program-level average include CSNJ, ELNJ, NBIL, OCOK, PXSS, ROIL, S4MO, TMOK, and TOOK. Sites with relatively low annual average concentrations (less than 1 µg/m³) other than BMCO include BRCO, RFCO, GLKY, SEWA, and PACO. Annual averages could not be calculated for ADOK, RICO, or YUOK.
- Figure 4-3 shows the inter-site variability graph for arsenic, which also includes a comparison of PM₁₀ results and TSP results. Note that only sites from Oklahoma are using TSP samplers. The program-level average concentration of arsenic (PM₁₀) is 0.67 ng/m³, while the program-level average concentration of arsenic (TSP) is 0.61 ng/m³. There is more variability across the program associated with the PM₁₀ measurements than the TSP measurements, as indicated by the range of annual averages as well as confidence intervals shown. Site-specific annual average arsenic concentrations range from 0.28 ng/m³ (UNVT) to 1.24 ng/m³ (ASKY-M) for PM₁₀ and 0.46 ng/m³ (OCOK) to 0.80 ng/m³ (TOOK) for TSP. Annual averages could not be calculated for ADOK and YUOK. BTUT has the most variability in the PM₁₀ measurements, while TOOK has the most variability in the TSP measurements, although the confidence intervals calculated for BTUT are nearly four times larger than those for TOOK.
- Figure 4-4a is the inter-site variability graph for benzene, as measured with Method TO-15. The program-level average concentration of benzene is 0.78 µg/m³. Site-specific annual average concentrations range from 0.37 µg/m³ (UNVT) to 1.56 µg/m³ (ANAK). Although the annual average concentrations for ANAK and ASKY are similar, the variability associated with the measurements collected at ASKY is considerably higher, as indicated by the confidence intervals shown in Figure 4-4a. Other sites with annual average concentrations greater than 1 µg/m³ include TROK, PXSS, TVKY, SPAZ, and TOOK. Sites with relatively low annual average concentrations (less than 0.5 µg/m³) other than UNVT include NBIL, GLKY, CHNJ, and CCKY.
- Figure 4-4b is the inter-site variability graph for benzene, as measured with the concurrent SNMOC method. Canister samples collected at seven sites are analyzed with this method. The program-level average concentration of benzene (SNMOC only) is 1.20 µg/m³. Site-specific annual average concentrations range from 0.56 µg/m³ (NBIL) to 1.96 µg/m³ (PACO). The annual average concentrations for PACO and RICO are greater than the program-level average; the annual average concentrations for NBIL and RFCO are less than the program-level average; and the annual average concentrations for BMCO, BRCO and BTUT are similar to the

program-level average benzene concentration (SNMOC only). Note that canisters from BTUT and NBIL are analyzed using both methods and their annual averages are similar although slightly higher using the SNMOC method.

- Figure 4-5a is the inter-site variability graph for 1,3-butadiene, as measured with Method TO-15. The program-level average concentration of 1,3-butadiene is $0.15 \mu\text{g}/\text{m}^3$. Site-specific annual average concentrations range from $0.006 \mu\text{g}/\text{m}^3$ (UNVT) to $1.03 \mu\text{g}/\text{m}^3$ (TVKY). It is easy to see which sites' concentrations are driving the program-level average concentration. While most sites' annual averages are less than the program-level average, including some whose annual averages are similar to or just greater than the MDL, the annual average concentrations for BLKY, LAKY, and TVKY are four or more times greater than the program-level average concentration of 1,3-butadiene. Another Calvert City, Kentucky site (CCKY) also has an annual average concentration greater than the program-level average, but to a lesser extent. Each of these sites has very large confidence intervals, indicating that outliers are likely influencing these annual average concentrations. The fifth Calvert City site, ATKY, has an annual average concentration that is significantly less than the other sites in that area.
- Figure 4-5b is the inter-site variability graph for 1,3-butadiene, as measured with the concurrent SNMOC method. Canister samples collected at seven sites are analyzed with this method. The program-level average concentration of 1,3-butadiene (SNMOC only) is $0.037 \mu\text{g}/\text{m}^3$. Site-specific annual average concentrations range from $0.004 \mu\text{g}/\text{m}^3$ (BMCO) to $0.11 \mu\text{g}/\text{m}^3$ (RICO). The annual average concentrations for BTUT and RICO are greater than the program-level average, with the annual average for RICO more than twice the program-level average, while the remaining annual average concentrations are less than the program-level average. However, with the exception of RICO, all of the annual average concentrations are less than the MDL for 1,3-butadiene with the SNMOC method. This means that the annual average concentrations shown incorporate data containing many zeroes substituted for non-detects, many concentrations that are less than the MDL, or a combination of both. The MDL for 1,3-butadiene is considerably higher for the SNMOC method ($0.104 \mu\text{g}/\text{m}^3$) than the TO-15 Method ($0.024 \mu\text{g}/\text{m}^3$). Because so many of the results are less than the MDL or non-detects, there is less certainty associated with the SNMOC results for this pollutant.
- The program-level average concentration of carbon tetrachloride is $0.66 \mu\text{g}/\text{m}^3$, as shown in blue in Figure 4-6. For most sites, the annual average concentration is either slightly less or slightly more than the program-level average concentration and the associated confidence levels are relatively small. This indicates that there is little variability in the carbon tetrachloride measurements across the program. This uniformity is not unexpected. Carbon tetrachloride is a pollutant that was used worldwide as a refrigerant. However, it was identified as an ozone-depleting substance in the stratosphere and its use was banned by the Montreal Protocol (EPA, 2015d). This pollutant has a long lifetime in the atmosphere, but slowly degrades over time. Today, its concentration in ambient air is fairly ubiquitous regardless of where it is measured. The annual average carbon tetrachloride concentrations for BLKY and TVKY are greater than annual averages for the remaining sites, particularly for

BLKY. With the exceptions of these two sites, the annual average concentrations of carbon tetrachloride range from 0.56 $\mu\text{g}/\text{m}^3$ for BTUT to 0.69 $\mu\text{g}/\text{m}^3$ for SEWA. Further, the confidence intervals for these sites are less than $\pm 0.04 \mu\text{g}/\text{m}^3$. For TVKY, the annual average concentration is $0.80 \pm 0.08 \mu\text{g}/\text{m}^3$, which is somewhat higher than the other NMP sites. For BLKY, the annual average concentration is $1.11 \pm 0.77 \mu\text{g}/\text{m}^3$. The confidence interval for this site's average concentration indicates that there is considerable variability in the carbon tetrachloride concentrations measured at this site and will be discussed in more detail in the Kentucky section (Section 14).

- Figure 4-7 presents the program-level and annual average concentrations of *p*-dichlorobenzene. This figure shows that the program-level average concentration ($0.044 \mu\text{g}/\text{m}^3$) and most of the site-specific annual average concentrations are less than the MDL for this pollutant ($0.14 \mu\text{g}/\text{m}^3$), as indicated by the dashed blue line. This indicates that many of the measurements are either non-detects or less than the detection limit. Table 4-1 shows that roughly half of the 2013 measurements of *p*-dichlorobenzene are non-detects and of the measured detections, 85 percent were less than the MDL. Only two sites have annual average concentrations greater than the MDL for this pollutant, PXSS and SPAZ. PXSS and SPAZ account for the greatest number of *p*-dichlorobenzene measurements greater than the MDL, 38 for PXSS and 22 for SPAZ. These two sites also accounted for the two highest annual average concentrations of this pollutant for the 2012 NMP report. Other sites with a higher number of measurements greater than the MDL include S4MO (16), TMOK (12), and ADOK (10). The maximum *p*-dichlorobenzene concentration, though, was measured at BTUT ($0.681 \mu\text{g}/\text{m}^3$), which is more than twice the next highest concentration and helps explain, at least partially, why the confidence interval is so large for a site with an annual average concentration similar to the program average concentration.
- Figure 4-8 shows that the annual average concentrations of 1,2-dichloroethane calculated for some of the Kentucky sites are significantly higher than the annual averages for other NMP sites as well as the program-level average concentration. Excluding the Calvert City sites, annual average concentrations of 1,2-dichloroethane range from $0.06 \mu\text{g}/\text{m}^3$ (SPAZ) to $0.11 \mu\text{g}/\text{m}^3$ (BTUT), which are all similar to or just greater than the MDL for this pollutant ($0.063 \mu\text{g}/\text{m}^3$). The annual average concentrations of 1,2-dichloroethane for the five Calvert City sites range from $0.24 \mu\text{g}/\text{m}^3$ (CCKY) to $3.75 \mu\text{g}/\text{m}^3$ (TVKY). The confidence intervals for these annual average concentrations are relatively large, indicating there is considerable variability in the measurements collected at these sites. These sites are driving the program-level average concentration ($0.26 \mu\text{g}/\text{m}^3$), which was a similar finding in the 2012 NMP report. Without the Calvert City sites, the program-level average concentration would be $0.08 \mu\text{g}/\text{m}^3$.
- Figure 4-9a is the inter-site variability graph for ethylbenzene, as measured with Method TO-15. The program-level average concentration of ethylbenzene is $0.36 \mu\text{g}/\text{m}^3$. Site-specific annual average concentrations range from $0.07 \mu\text{g}/\text{m}^3$ (UNVT) to $1.95 \mu\text{g}/\text{m}^3$ (KMMS). The annual average concentration for KMMS is considerably higher than the next highest annual average concentration ($0.89 \mu\text{g}/\text{m}^3$).

for ANAK), and has a very large confidence interval associated with it. The only other sites with annual average concentrations greater than $0.5 \mu\text{g}/\text{m}^3$ are PXSS and SPAZ. Sites with relatively low annual average concentrations (less than $0.15 \mu\text{g}/\text{m}^3$) other than UNVT include CCKY, ATKY, CHNJ, TVKY, GLKY, and BLKY.

- Figure 4-9b is the inter-site variability graph for ethylbenzene, as measured with the concurrent SNMOC method. Canister samples collected at seven sites are analyzed with this method. The program-level average concentration of ethylbenzene (SNMOC only) is $0.25 \mu\text{g}/\text{m}^3$. Site-specific annual average concentrations range from $0.11 \mu\text{g}/\text{m}^3$ (BRCO) to $0.56 \mu\text{g}/\text{m}^3$ (BTUT). The annual average concentrations for BTUT and RICO are greater than the program-level average; the annual average concentrations for the remaining sites are less than the program-level average concentration. Note that canisters from BTUT and NBIL are analyzed using both methods and their annual averages are similar although slightly higher using the SNMOC method.
- The program-level average concentration of formaldehyde is $2.83 \mu\text{g}/\text{m}^3$, as shown in purple in Figure 4-10. Site-specific annual average concentrations range from $0.57 \mu\text{g}/\text{m}^3$ (SEWA) to $8.05 \mu\text{g}/\text{m}^3$ (BTUT). This is the third year in a row that BTUT has had the highest annual average concentration of formaldehyde among NMP sites. The annual average concentrations for BTUT and GPCO are more twice the program-level average for formaldehyde, with all other NMP sites having annual average concentrations less than $5 \mu\text{g}/\text{m}^3$. Sites with relatively low annual average concentrations (less than $1 \mu\text{g}/\text{m}^3$) other than SEWA include BRCO, BMCO, and RFCO. Annual averages could not be calculated for ADOK, RICO, or YUOK.
- Figure 4-11 presents the program-level and site-specific annual average concentrations of hexachloro-1,3-butadiene. This figure shows that the program-level average concentration ($0.014 \mu\text{g}/\text{m}^3$) and all of the site-specific annual average concentrations are considerably less than the MDL for this pollutant ($0.304 \mu\text{g}/\text{m}^3$), as indicated by the dashed blue line. None of the hexachloro-1,3-butadiene measurements collected in 2013 were greater than the detection limit, as indicated in Table 4-1. Of the 1,883 valid VOC samples collected, only 330 (or 18 percent) included measured detections of hexachloro-1,3-butadiene. This indicates that a large number of substituted zeroes are included in the annual averages shown in Figure 4-11, which generally pull the averages down.
- Figure 4-12 presents the program-level and site-specific annual average concentrations of naphthalene. The program-level average concentration ($75.26 \text{ ng}/\text{m}^3$), as well as all of the annual average concentrations, where they could be calculated, are considerably greater than the MDL for this pollutant. The site-specific annual averages varied considerably, from $10.62 \text{ ng}/\text{m}^3$ (UNVT) to $155.94 \text{ ng}/\text{m}^3$ (NBIL). The sites with the highest variability in their measurements, as indicated by the magnitude of their confidence intervals, are NBIL and WPFL. Concentrations measured at WPFL range from $4.32 \text{ ng}/\text{m}^3$ to $506 \text{ ng}/\text{m}^3$; concentrations measured at NBIL range from $2.87 \text{ ng}/\text{m}^3$ to $748 \text{ ng}/\text{m}^3$.

- Figure 4-13 shows the inter-site variability graph for nickel, which also includes a comparison of PM₁₀ results and TSP results. Note that only sites from Oklahoma are using TSP samplers. The program-level average concentration of nickel (PM₁₀) is 1.24 ng/m³, while the program-level average concentration of nickel (TSP) is 1.30 ng/m³. There is more variability across the program associated with the PM₁₀ measurements than the TSP measurements, as indicated by the range of annual averages as well as confidence intervals shown. Site-specific annual average nickel concentrations range from 0.36 ng/m³ (GLKY) to 2.40 ng/m³ (ASKY-M) for PM₁₀ and 0.84 ng/m³ (OCOK) to 2.09 ng/m³ (TOOK) for TSP. Annual averages could not be calculated for ADOK and YUOK. ASKY-M has the most variability in the PM₁₀ measurements, with nickel measurements spanning two orders of magnitude, ranging from 0.20 ng/m³ to 21.2 ng/m³. TOOK has the most variability in the TSP nickel measurements, ranging from 0.69 ng/m³ to 10.98 ng/m³.

Figure 4-1. Inter-Site Variability for Acenaphthene

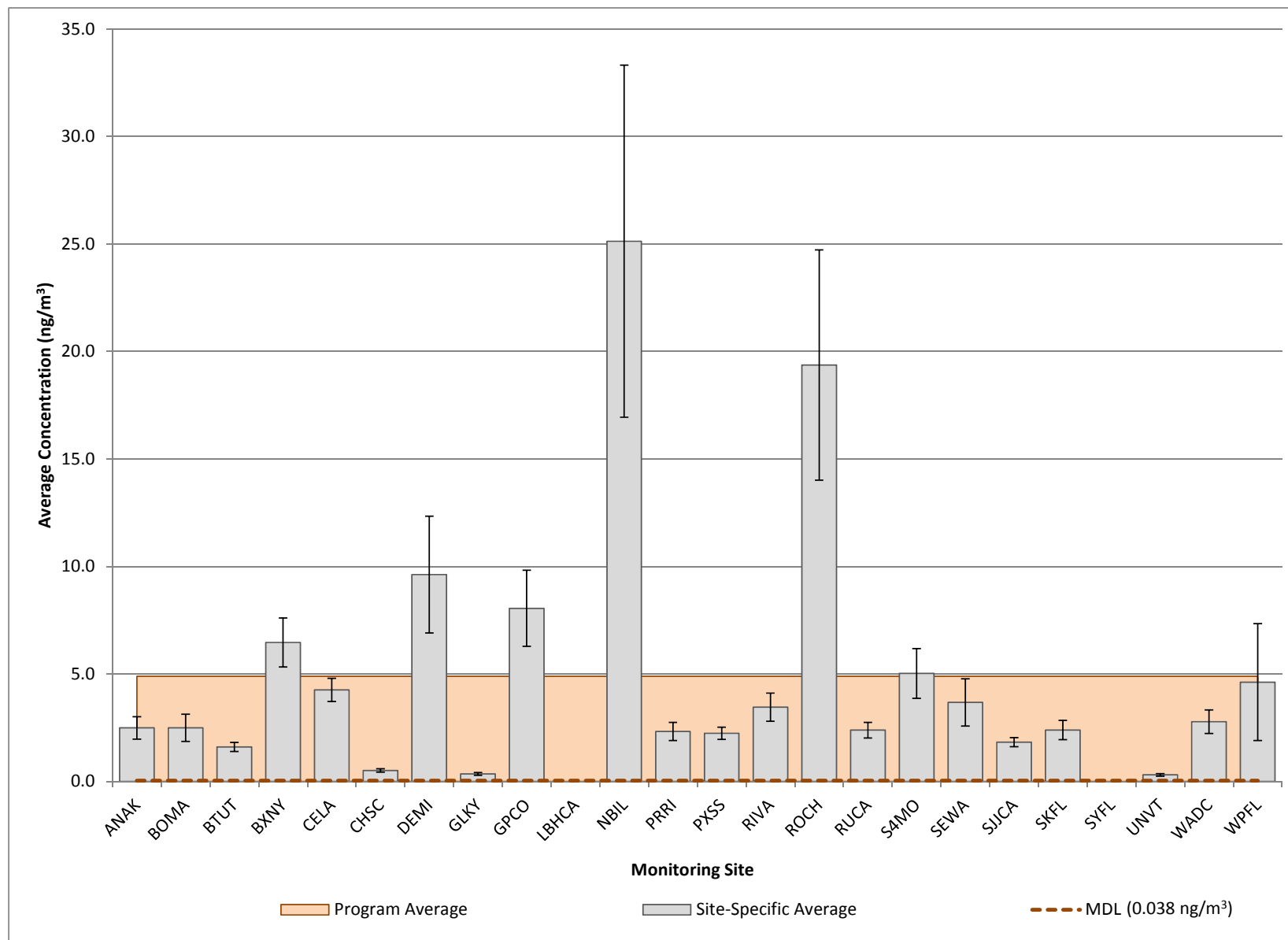


Figure 4-2. Inter-Site Variability for Acetaldehyde

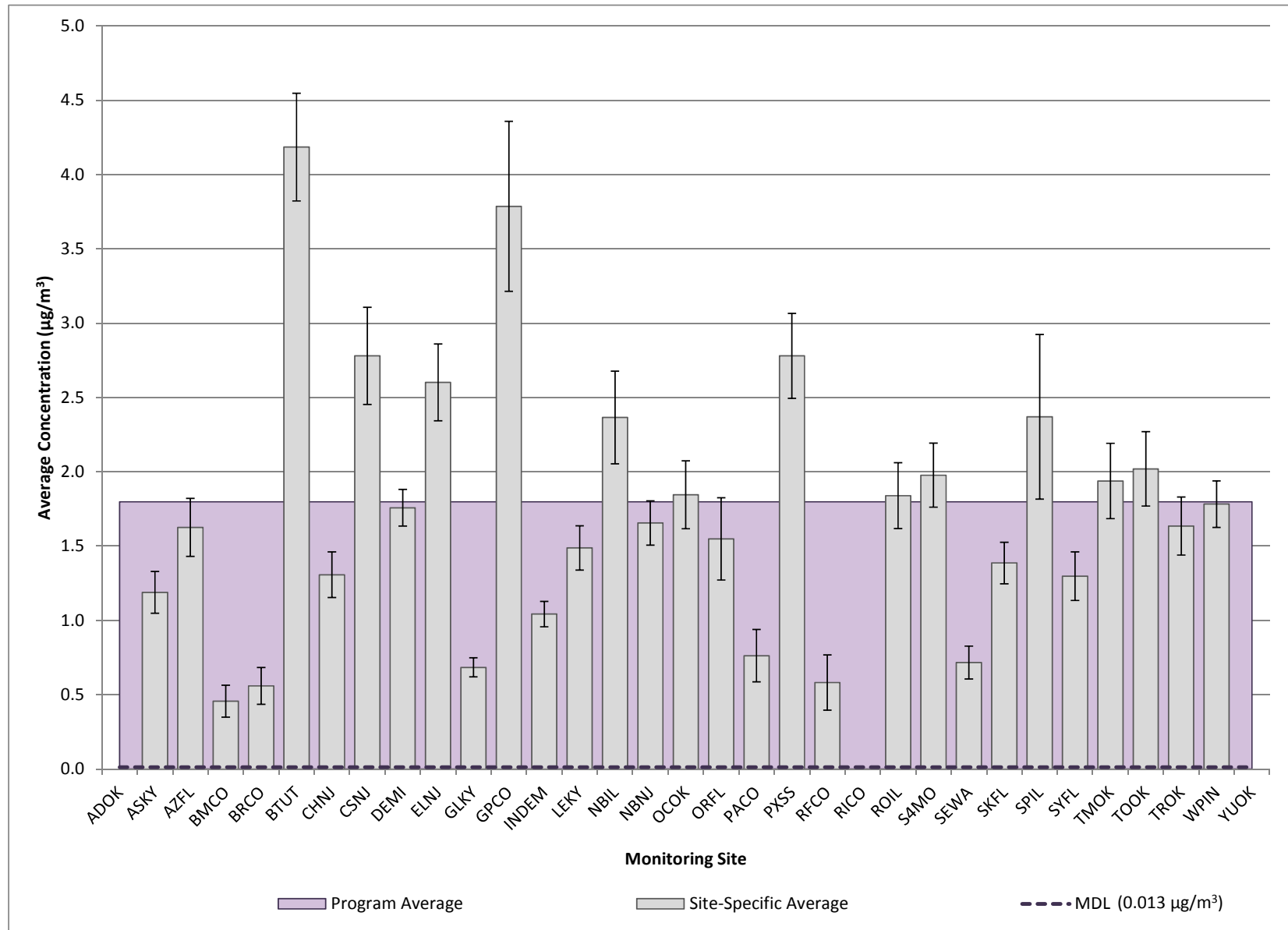


Figure 4-3. Inter-Site Variability for Arsenic

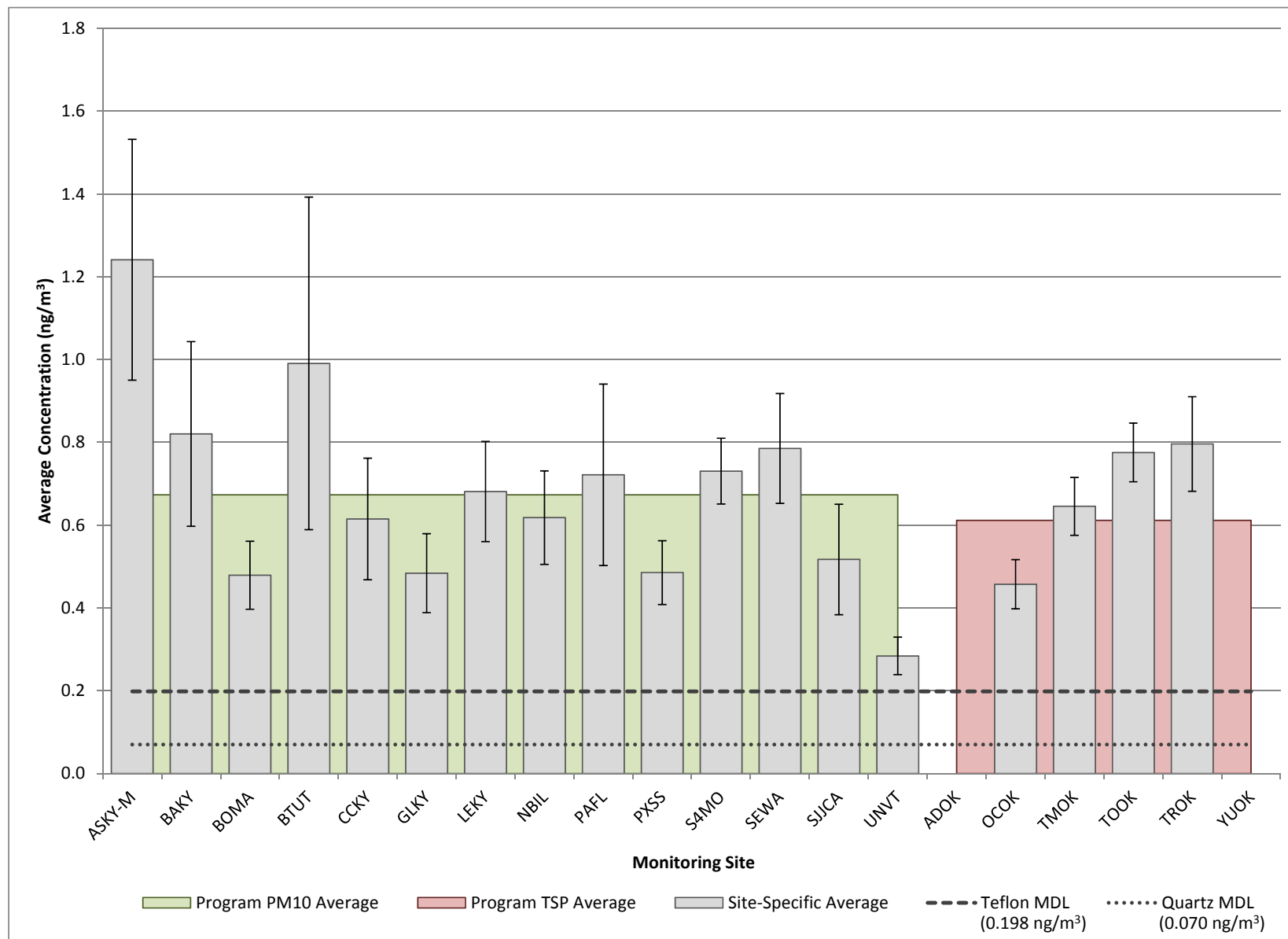


Figure 4-4a. Inter-Site Variability for Benzene - Method TO-15

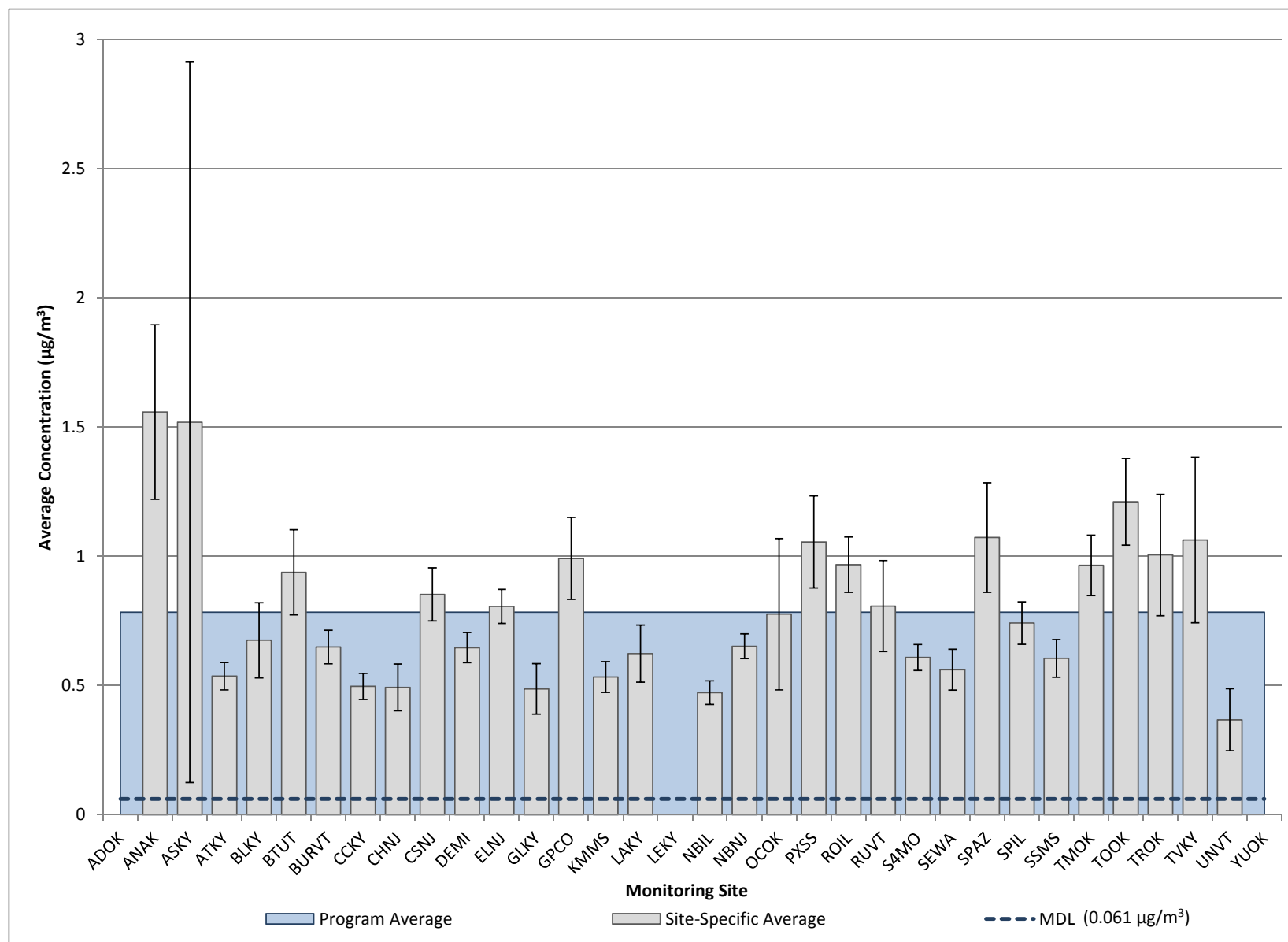


Figure 4-4b. Inter-Site Variability for Benzene – SNMOC

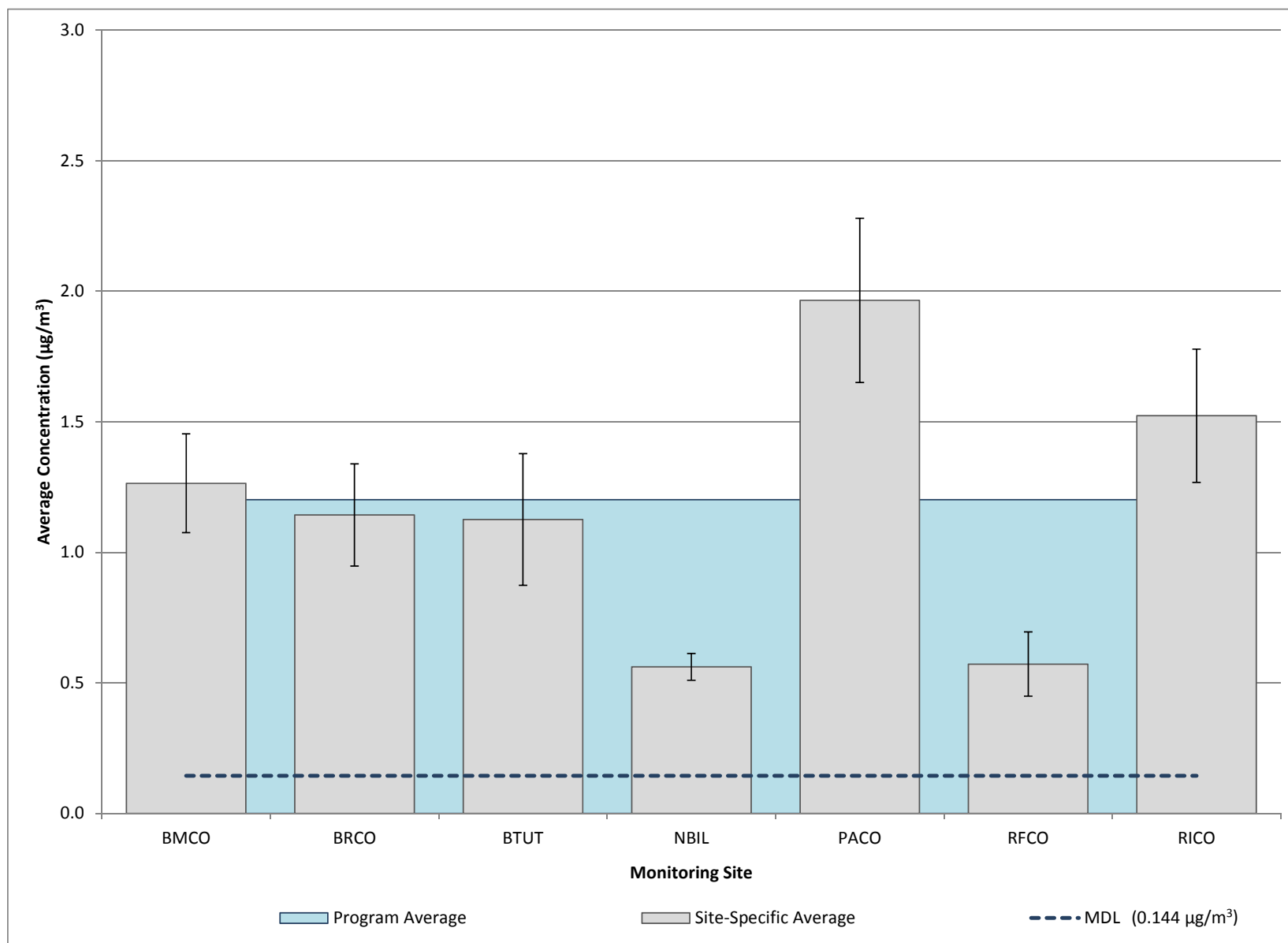


Figure 4-5a. Inter-Site Variability for 1,3-Butadiene – Method TO-15

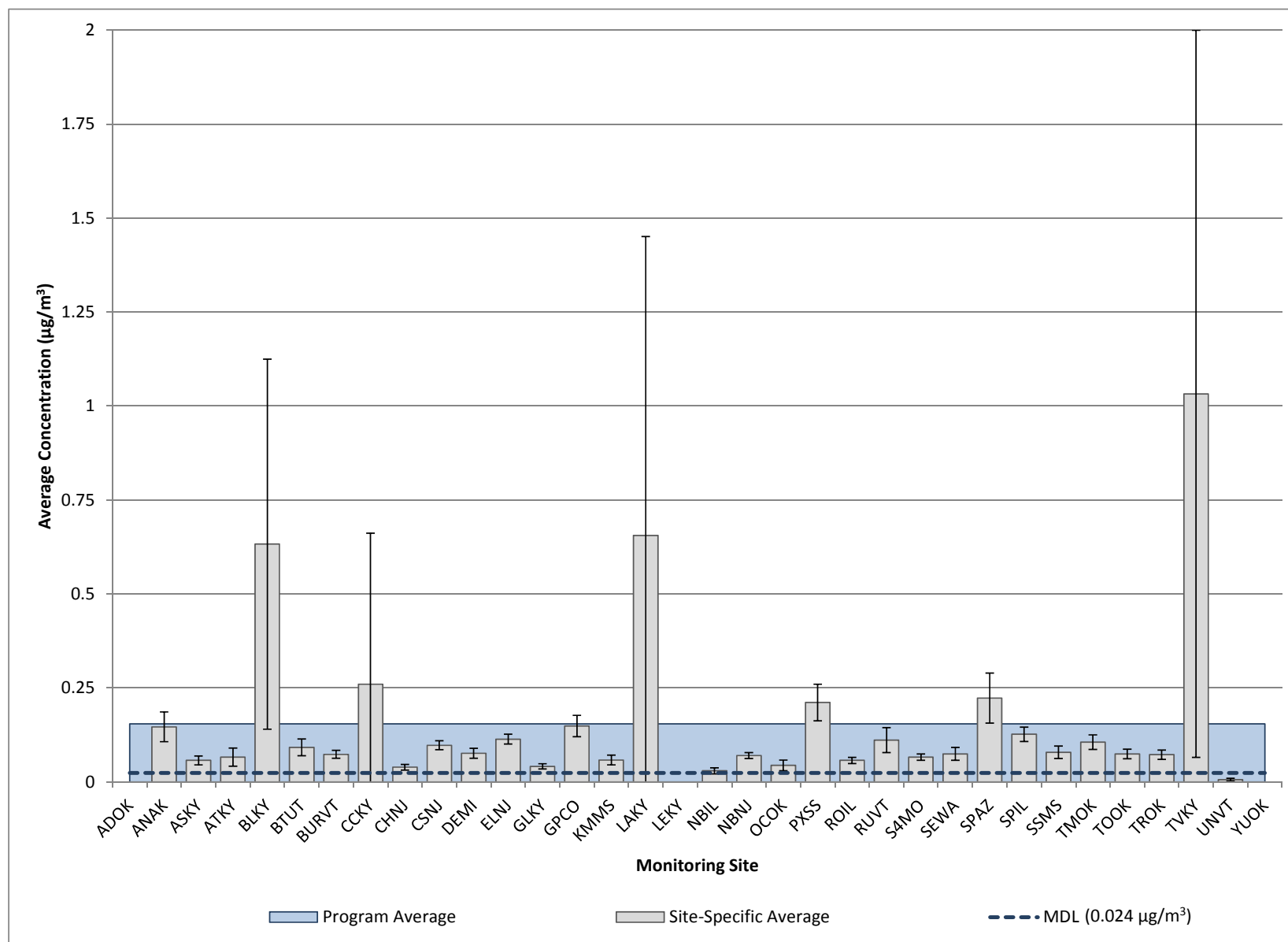


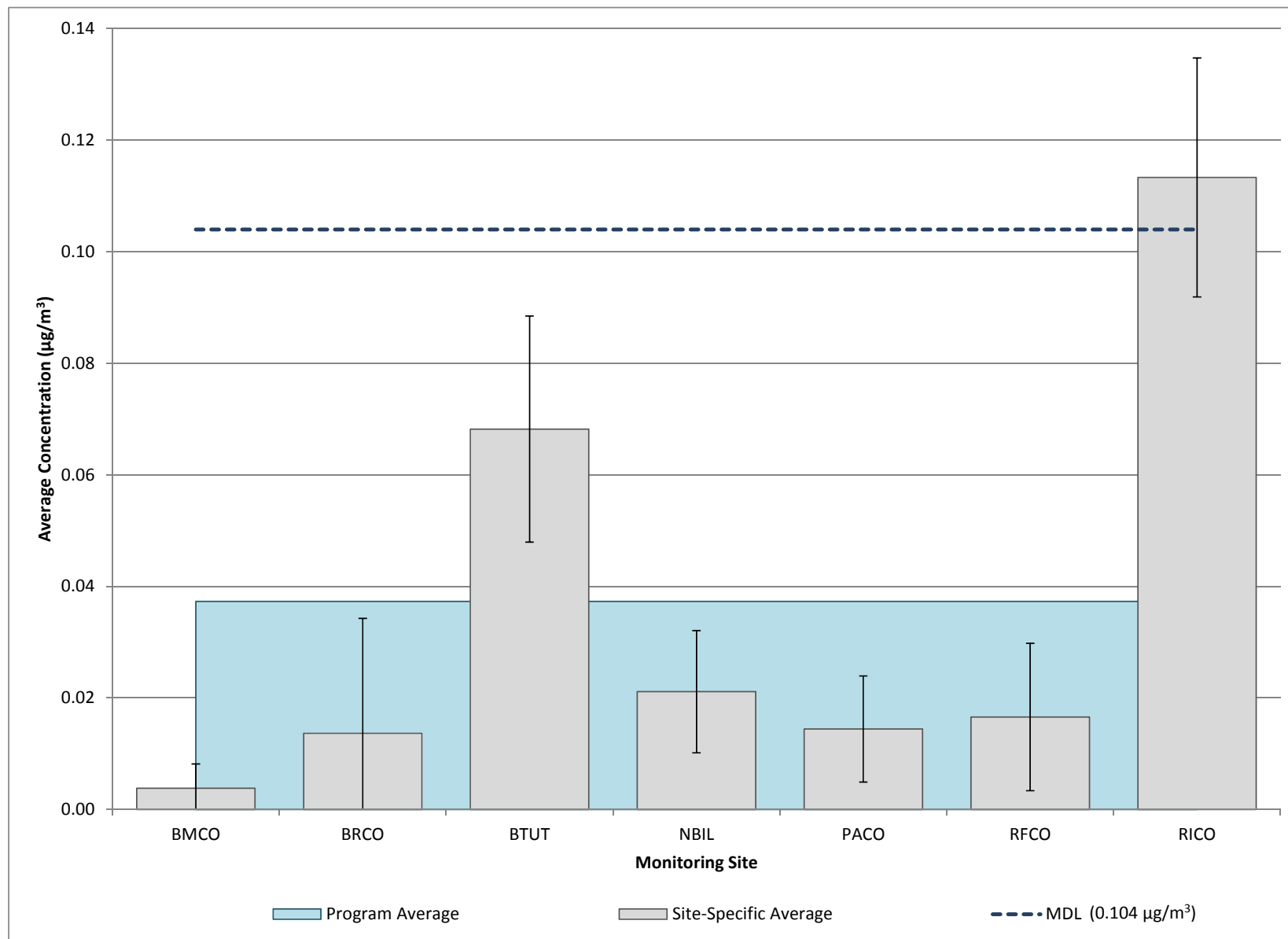
Figure 4-5b. Inter-Site Variability for 1,3-Butadiene - SNMOC

Figure 4-6. Inter-Site Variability for Carbon Tetrachloride

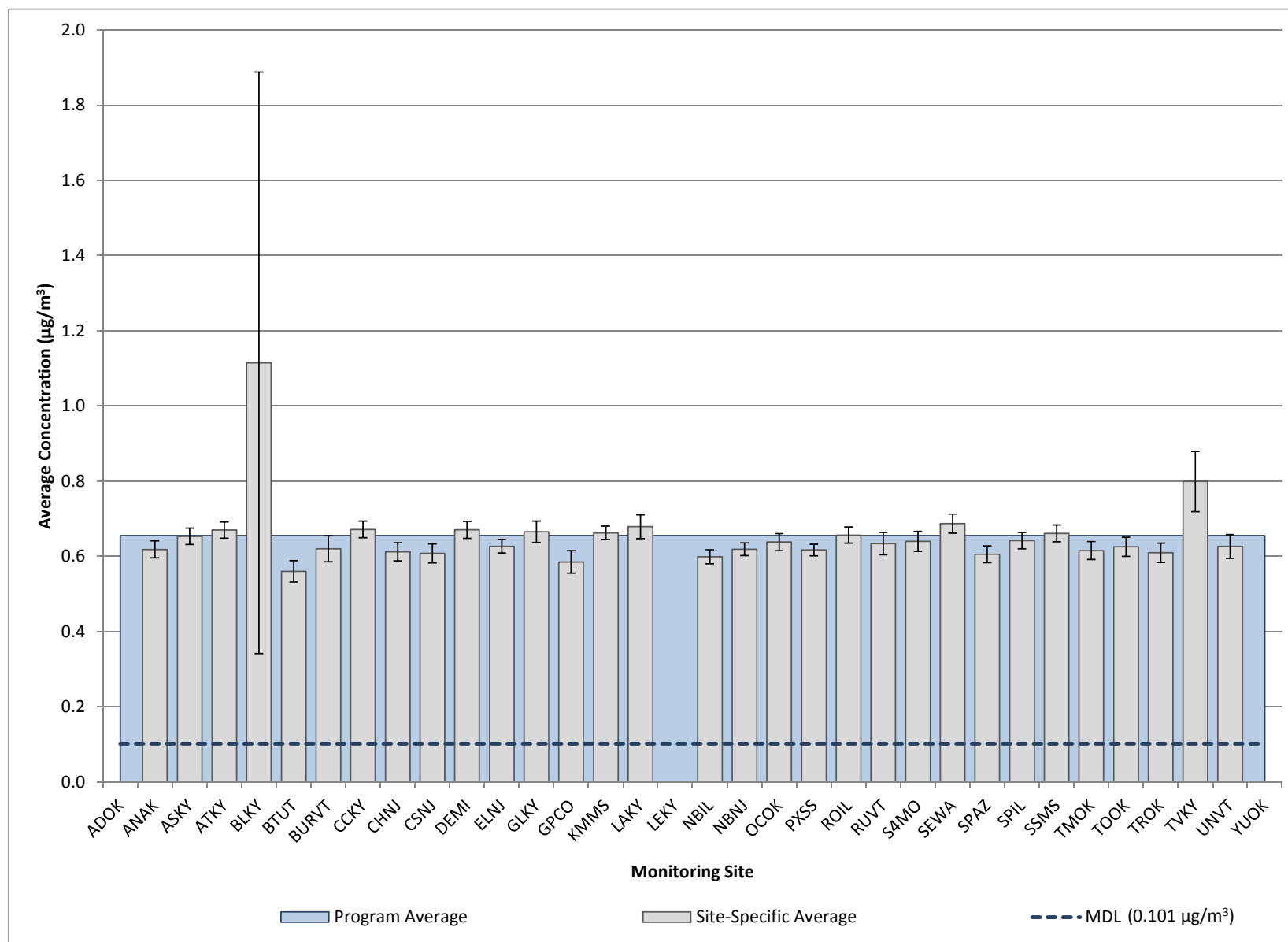


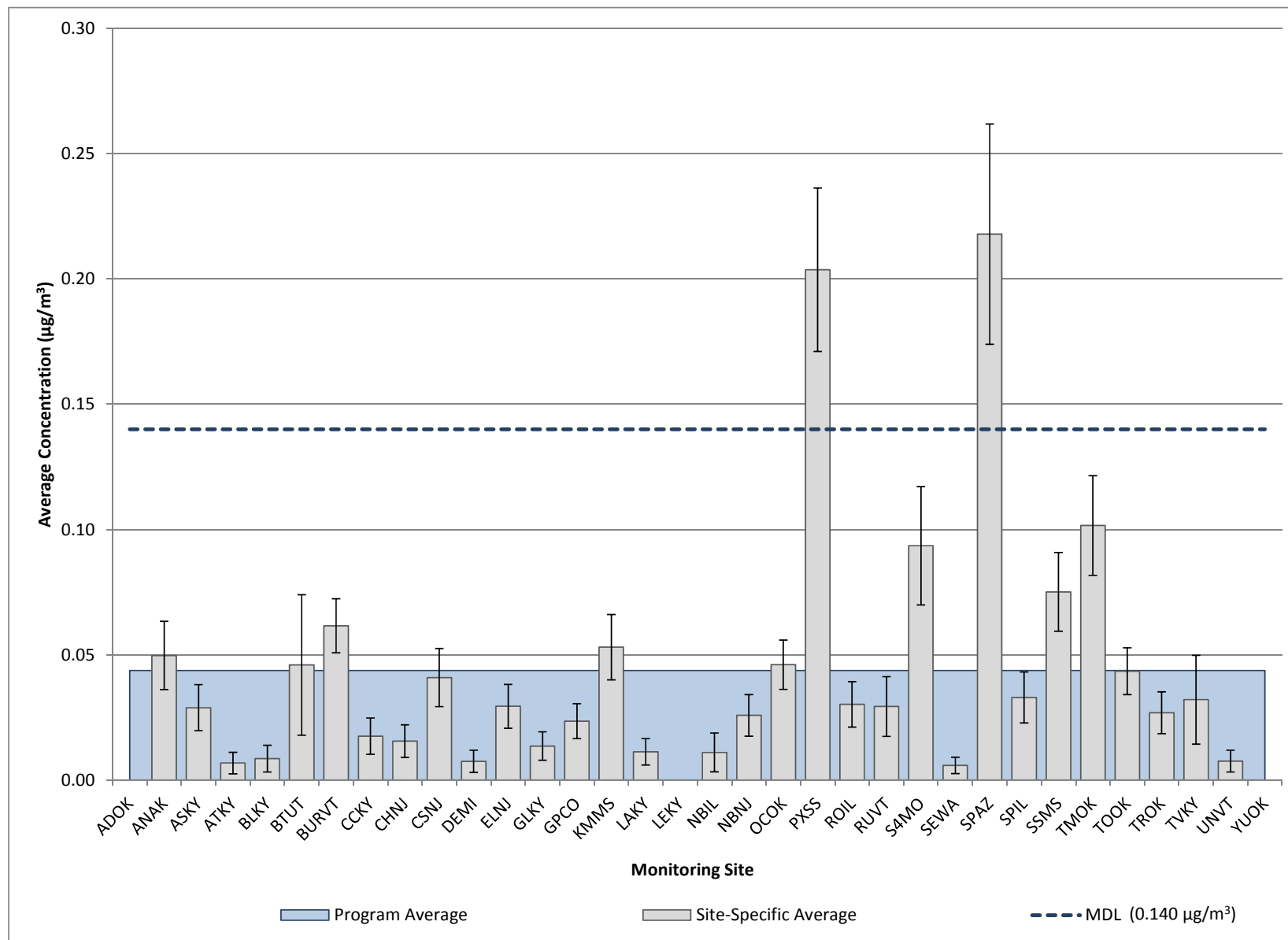
Figure 4-7. Inter-Site Variability for *p*-Dichlorobenzene

Figure 4-8. Inter-Site Variability for 1,2-Dichloroethane

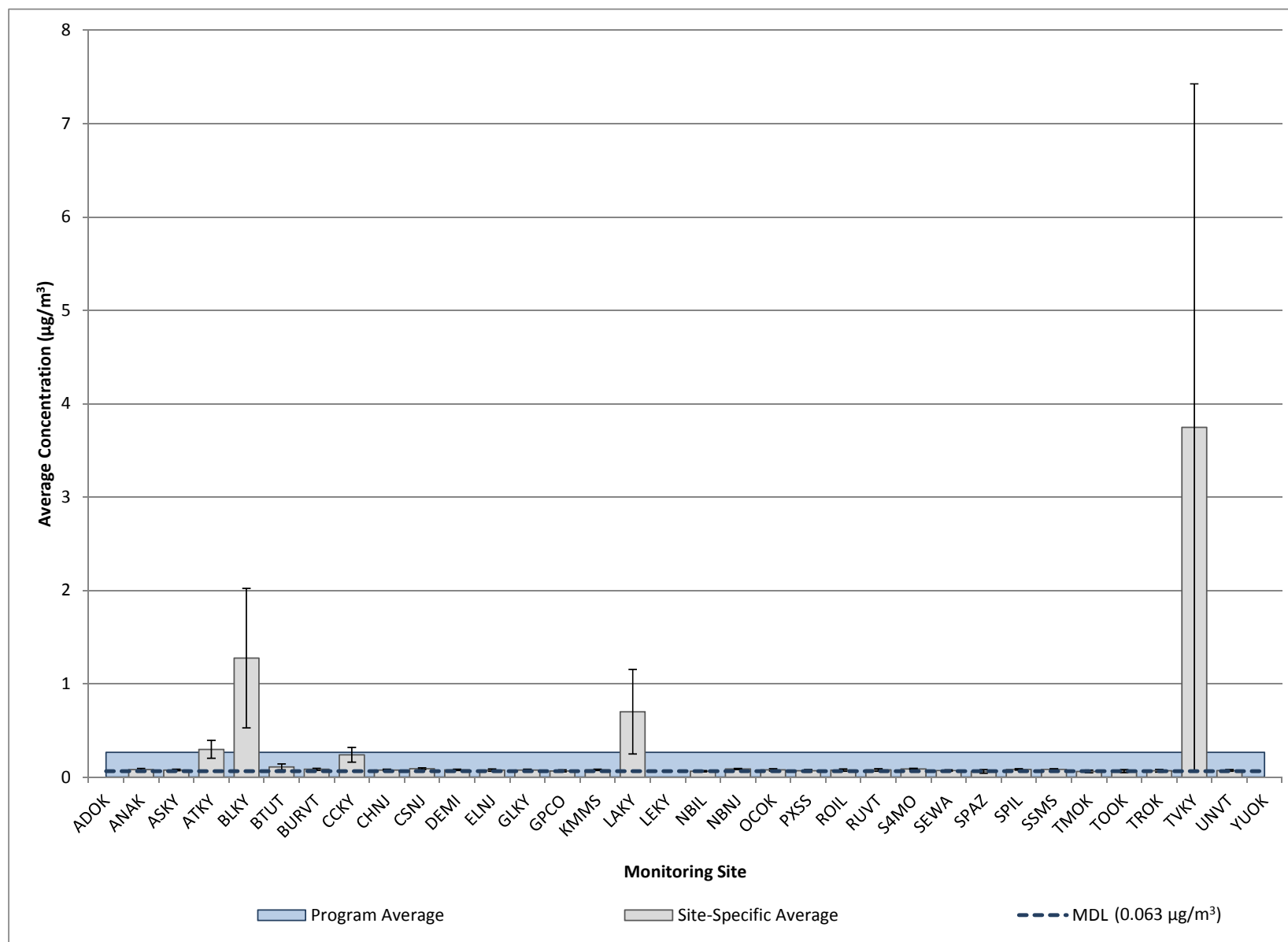


Figure 4-9a. Inter-Site Variability for Ethylbenzene – Method TO-15

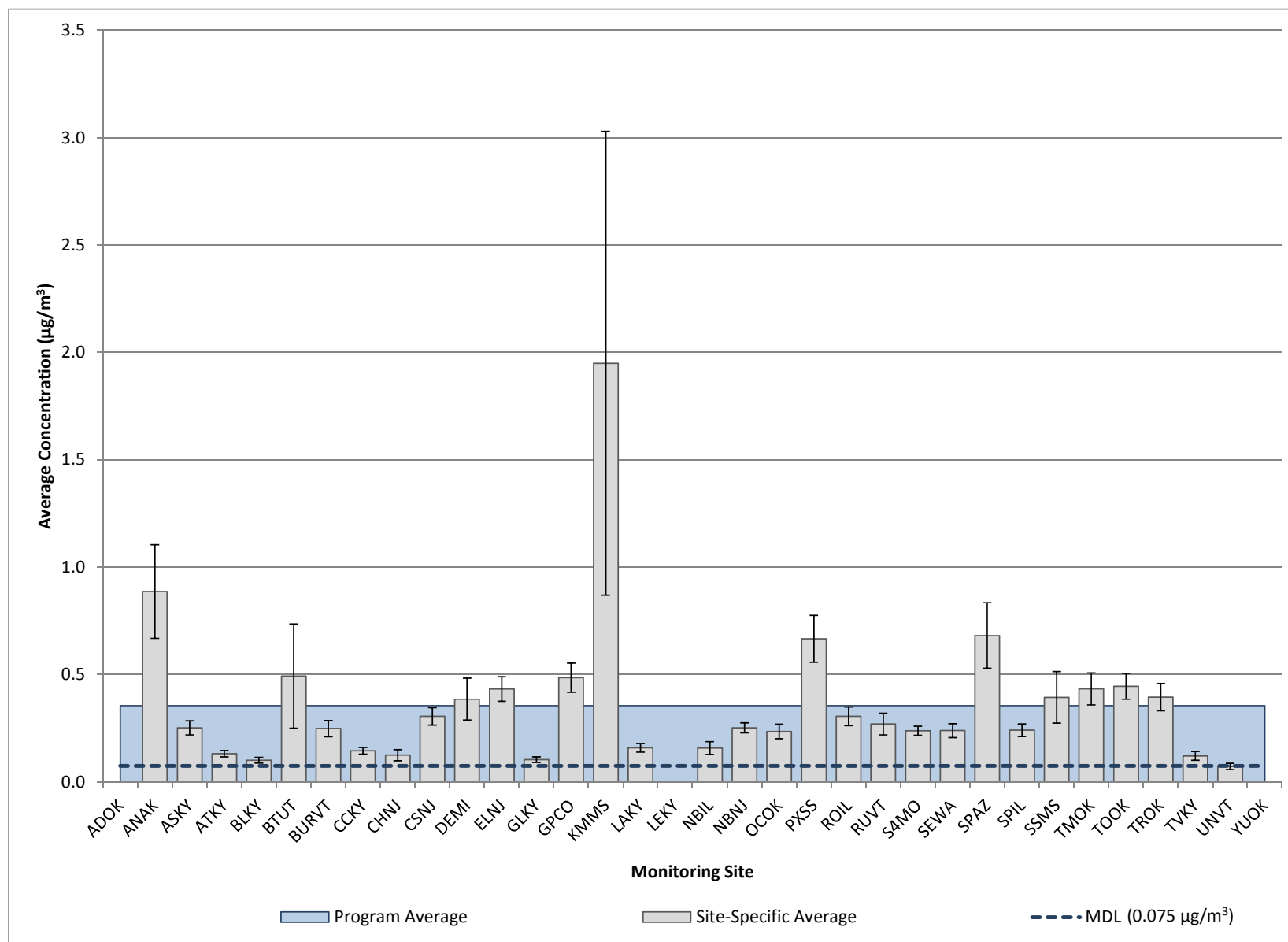


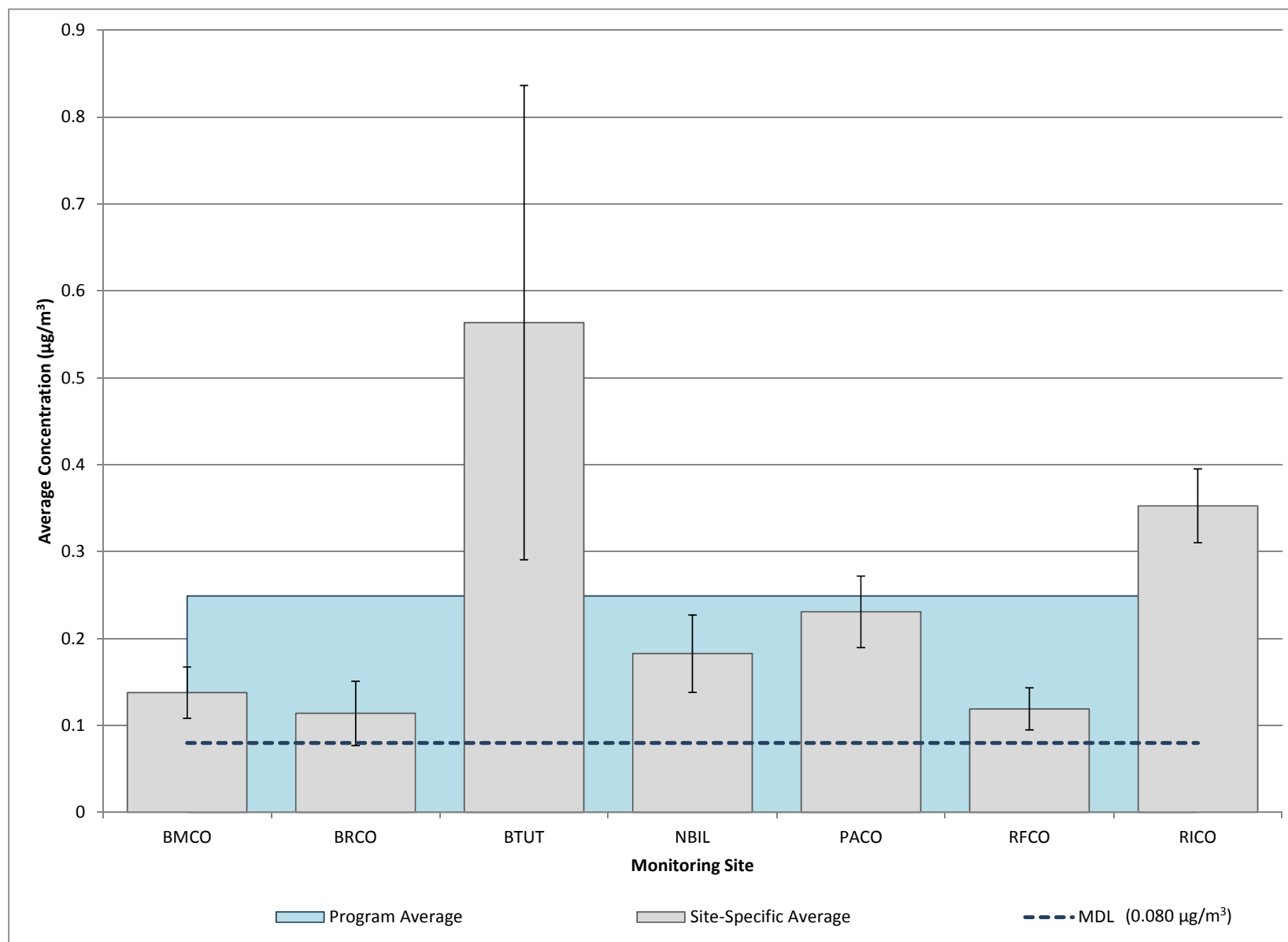
Figure 4-9b. Inter-Site Variability for Ethylbenzene - SNMOC

Figure 4-10. Inter-Site Variability for Formaldehyde

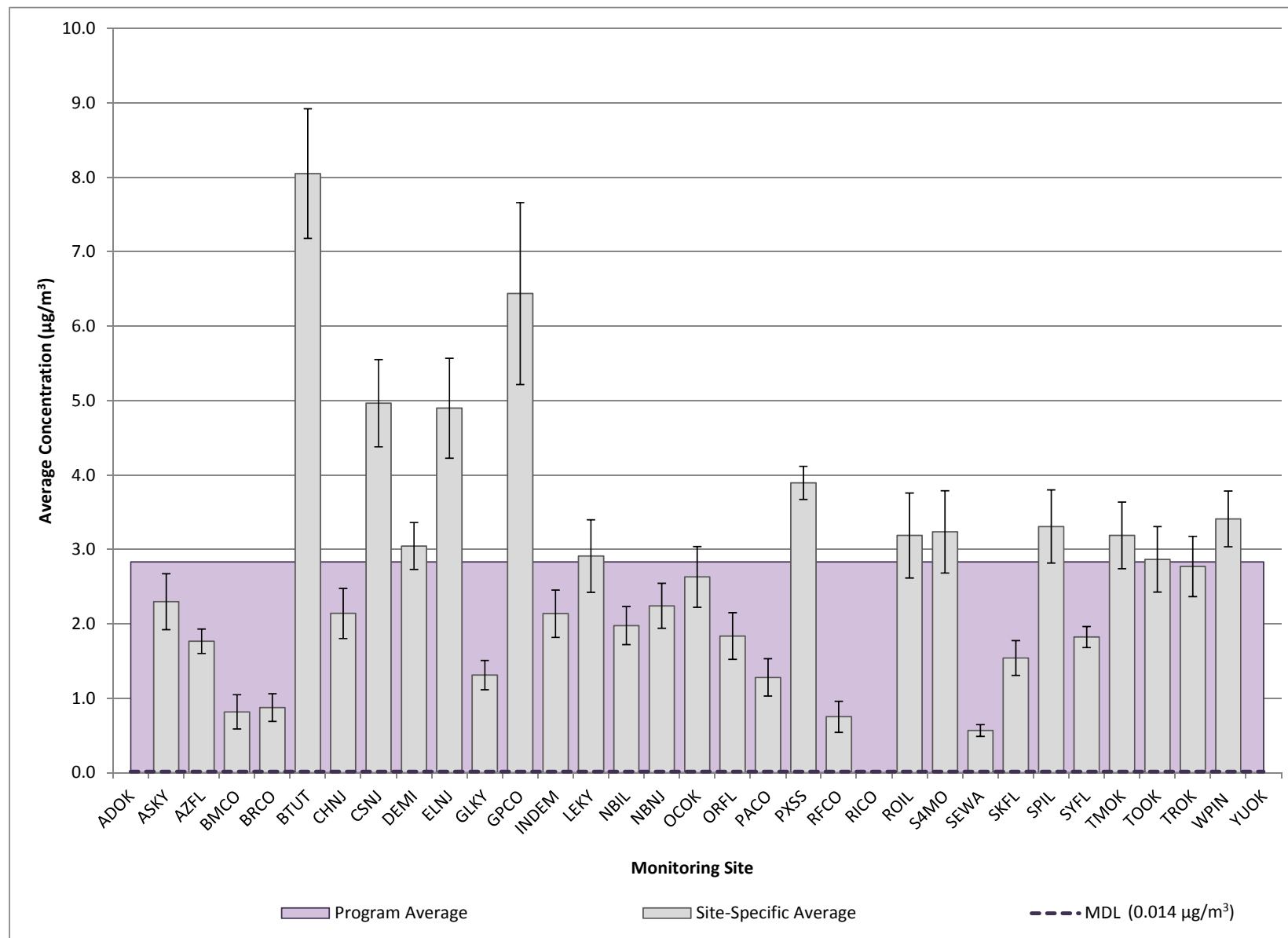


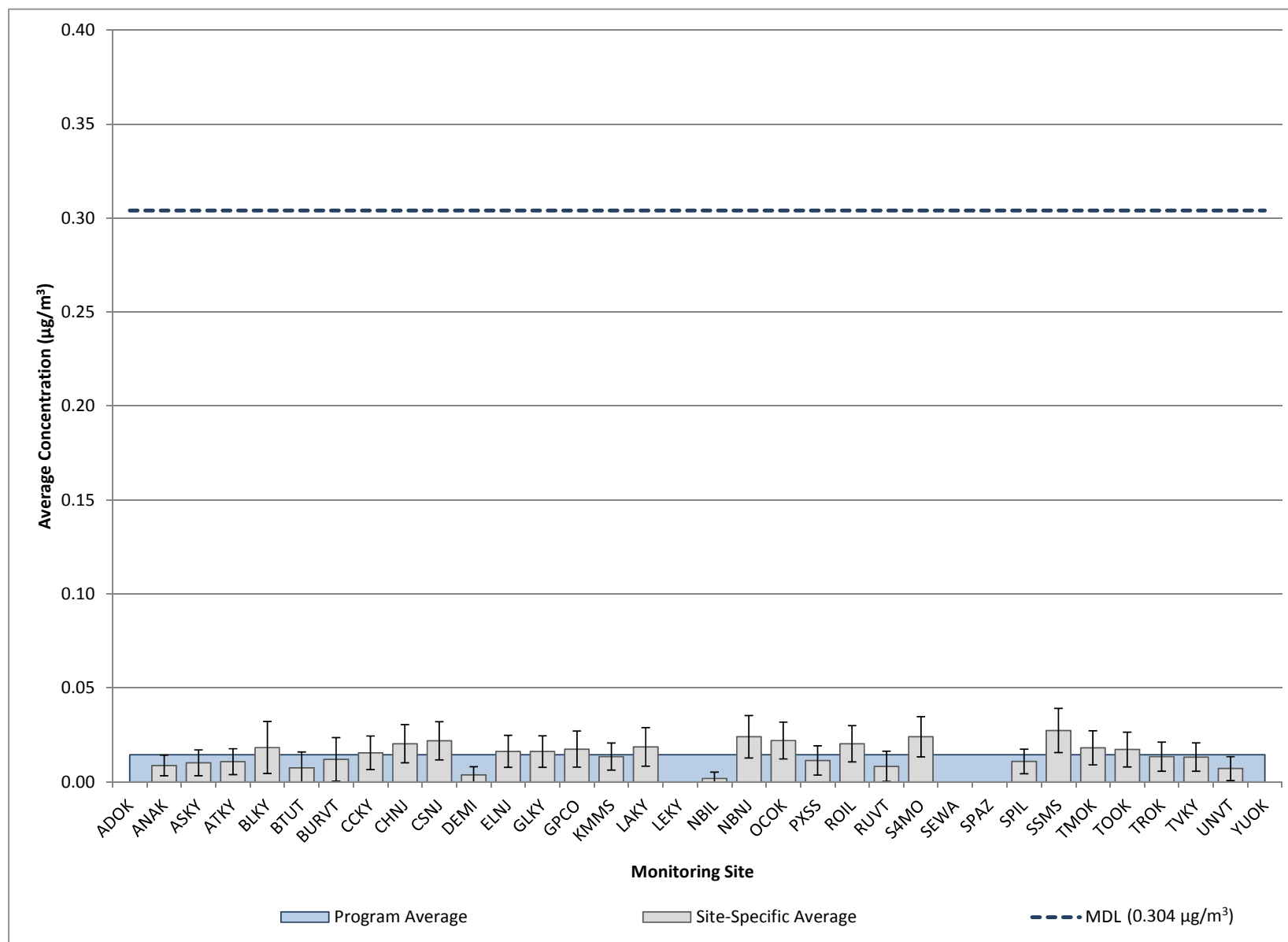
Figure 4-11. Inter-Site Variability for Hexachloro-1,3-butadiene

Figure 4-12. Inter-Site Variability for Naphthalene

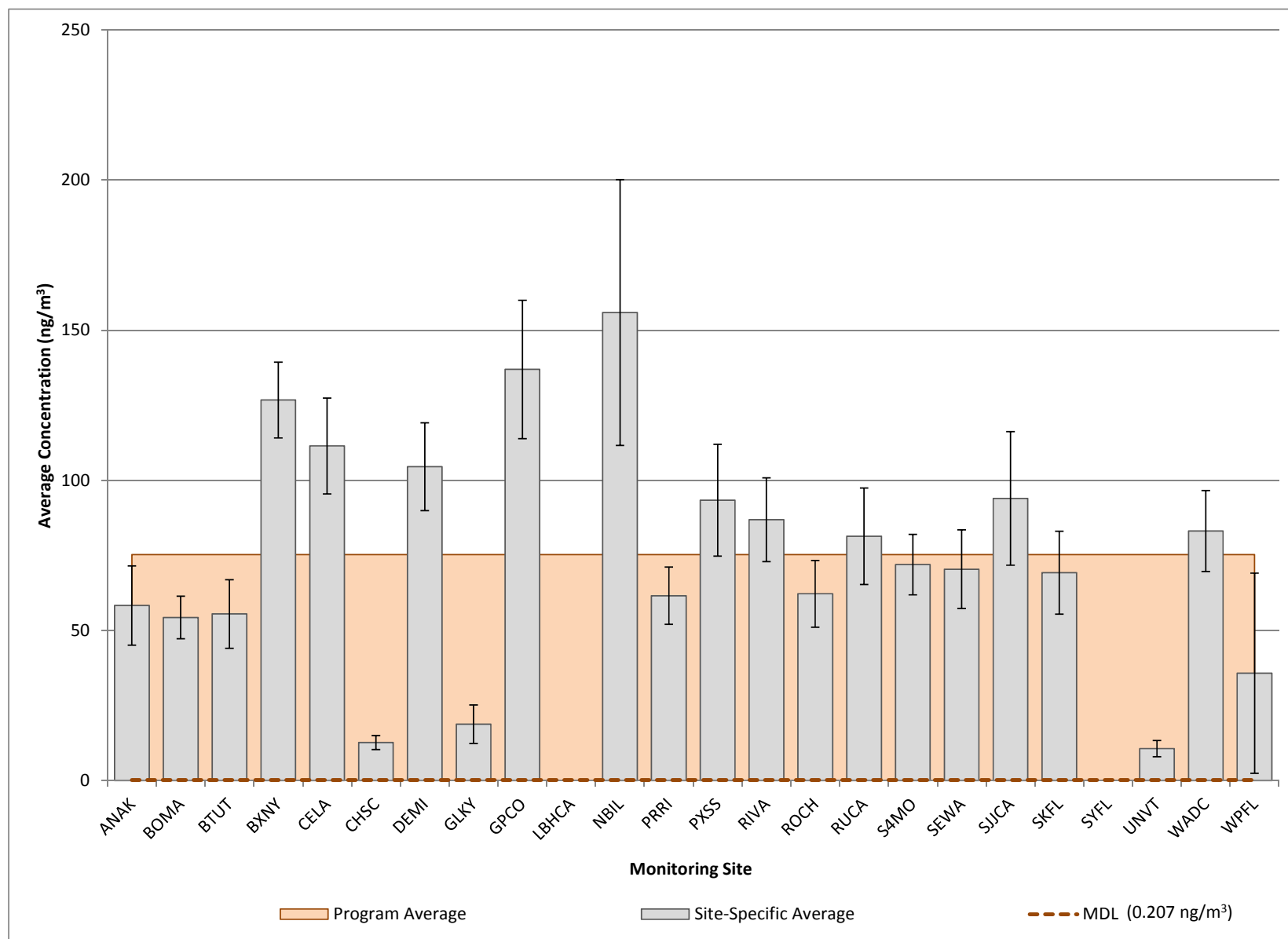
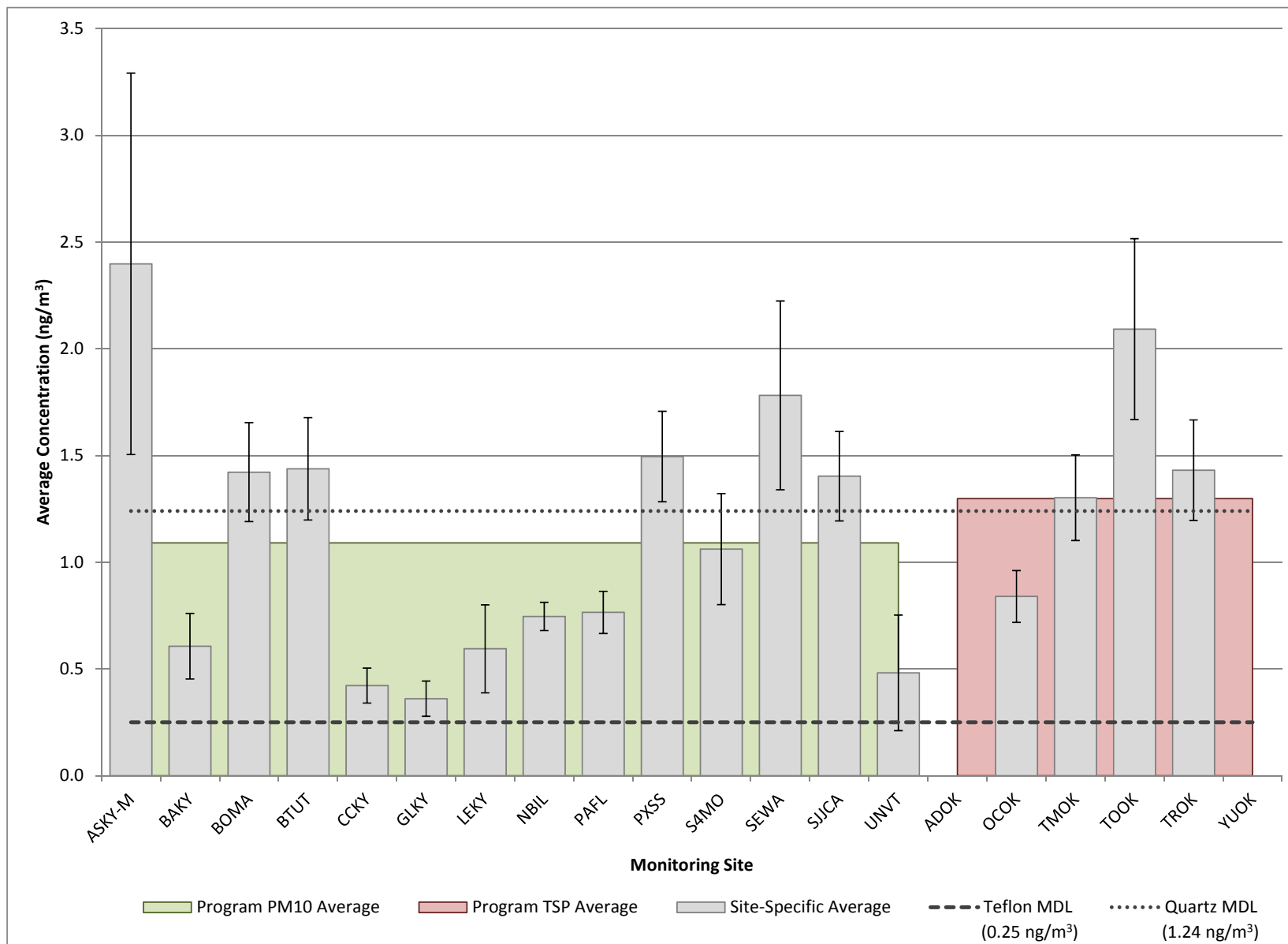


Figure 4-13. Inter-Site Variability for Nickel



4.4.2 Quarterly Variability Analysis

Figures 4-14 through 4-26 provide a graphical display of the site-specific quarterly average concentrations for each of the program-level pollutants of interest. Quarterly averages are calculated based on the criteria specified in Section 3.1. The published MDL from the ERG laboratory is also plotted on each graph, similar to the inter-site variability graphs. Note that the scales on the PM₁₀ and TSP graphs are the same for a given speciated metal. The same is also true for the air toxics measured by both Method TO-15 and the concurrent SNMOC method.

Missing quarterly averages in the figures for the pollutants of interest can be attributed to several reasons. First, some of the program-wide pollutants of interest were infrequently detected in some quarters and thus have a quarterly average concentration of zero as a result of the substitution of zeros for non-detects. Another reason for missing quarterly averages in the figures is due to the sampling duration of each site. Some sites started late or ended early in the year, which may result in a lack of quarterly averages. In addition, the criteria in Section 3.1 require a site to have 75 percent of the possible samples within a given calendar quarter (12 for a site sampling on a 1-in-6 day schedule). No quarterly average concentration is presented for sites that did not meet this criterion.

Most of the program-level pollutants of interest were detected year-round. Few were detected less frequently. For instance, hexachloro-1,3-butadiene was not detected at every site, as shown in Figure 4-24. This pollutant was not detected at BTUT, SEWA, or SPAZ, and was detected in two or fewer quarters at another three sites. However, comparing the quarterly averages for sites with four valid quarterly averages in a year may reveal a temporal trend for other pollutants. Examples of this include the following:

- Quarterly averages of formaldehyde tend to be highest for the summer months, based on previous reports. Figure 4-23 shows that 17 of the 33 sites sampling formaldehyde exhibited the highest quarterly average for the third quarter (from July through September), which is shown in green. In addition, another 13 sites exhibited their highest quarterly formaldehyde average for the second quarter (from April and June), which is shown in red. Thus, it appears that formaldehyde concentrations tend to be highest during the warmer months of the year, although there are exceptions.
- Conversely, benzene averages tend to be higher for the winter months. As shown in Figure 4-17a, 21 sites have their highest quarterly benzene concentration for the first quarter (shown in blue) and another nine exhibited their highest quarterly

average for the fourth quarter (shown in purple). Similarly, two sites have their highest quarterly benzene concentration for the first quarter and three sites exhibited their highest quarterly average for the fourth quarter (shown in purple) for those sampling benzene with the SNMOC method, as shown in Figure 4-17b. Note, however, that for those sampling with the SNMOC method, few sites have a quarterly average concentrations shown for all four quarters of the year.

- Other notable trends include 1,3-butadiene with higher concentrations in the first and fourth quarters, acenaphthene with higher concentrations in the second and third quarters, and acetaldehyde with higher concentrations in the second and third quarters.
- Concentrations of some pollutants had a tendency to be higher in one quarter over the others but the differences among the quarters were so small, it makes little difference. For instance, 20 of the 34 sites sampling 1,2-dichloroethane have their maximum quarterly average concentration for the second quarter of the year. But a review of the quarterly average concentrations in Figure 4-21 shows that the quarterly averages varied little for most of the sites. A similar observation can be made for carbon tetrachloride in Figure 4-19. Twenty-seven of the 34 sites sampling VOCs have their maximum quarterly average carbon tetrachloride concentration for either the second or third quarter of 2013, but the quarterly average concentrations for all but one monitoring site vary by less than $0.15 \mu\text{g}/\text{m}^3$.

The quarterly average concentration comparison also allows for the identification of sites with unusually high concentrations of the pollutants of interest compared to other sites and when those high concentrations were measured. The quarterly average graphs may also reveal if concentrations measured at a particular site are significantly lower than other sites. These graphs may also reveal when there is very little variability in the quarterly averages across other sites. Inter-state trends may also be revealed. Examples include the following:

- Figure 4-14 for acenaphthene shows that the second and third quarter average concentrations for NBIL and ROCH were considerably higher than their other quarterly averages, as well as those calculated for other sites.
- Figure 4-15 is the quarterly average graph for acetaldehyde. This figure shows that the quarterly averages are fairly variable. Of note, the quarterly averages for the Garfield County, Colorado sites tended to be the lowest of NMP sites sampling acetaldehyde. BMCO, BRCO, PACO, and RFCO, in addition to GLKY and SEWA, are the only sites with all four quarterly average concentrations of acetaldehyde less than $1 \mu\text{g}/\text{m}^3$.
- ASKY-M is the only monitoring site for which all four quarterly average concentrations of arsenic are greater than $1 \text{ ng}/\text{m}^3$, as shown in Figures 4-16a and

4-16b. BTUT's fourth quarter average concentration is the only quarterly average among the sites sampling arsenic that is greater than 2 ng/m³.

- ANAK's first and fourth quarter average benzene concentrations are both greater than 2 µg/m³, as shown in Figures 4-17a and 4-17b, as are RICO's; PACO's fourth quarter average concentration is greater than 2.50 µg/m³. ASKY's fourth quarter average concentration is the only quarterly average among NMP sites sampling benzene that is greater than 3 µg/m³.
- Figures 4-18a and 4-18b are the quarterly average graphs for 1,3-butadiene. Figure 4-18a shows that the second and fourth quarter average concentrations for three of the Calvert City, Kentucky sites (BLKY, LAKY, and TVKY) are considerably higher than the quarterly average concentrations calculated for other NMP sites. This is also true for the fourth quarter average concentration for CCKY. The ATKY monitoring site is also located in Calvert City, but does not reflect this trend. The first and fourth quarter averages for PXSS and SPAZ are also greater than most sites' quarterly average concentrations of 1,3-butadiene. For sites sampling SNMOCs, only RICO has quarterly average concentrations greater than the MDL for this pollutant.
- Figure 4-19 is the quarterly average graph for carbon tetrachloride. Nearly all of the quarterly average concentrations calculated for each site fall within a relatively small range, generally between 0.50 µg/m³ and 0.75 µg/m³. However, there are two exceptions to this. All four quarterly average concentrations for TVKY are greater than 0.75 µg/m³, ranging from 0.76 µg/m³ for the fourth quarter of 2013 to 0.85 µg/m³ for the first quarter of 2013. Three of the four quarterly average concentration for BLKY are greater than 0.75 µg/m³, including the first quarter average concentration, which is 2.21 µg/m³. The quarterly average concentrations for the remaining Calvert City sites do not reflect this trend.
- Nearly all of the quarterly average concentrations of *p*-dichlorobenzene are less than the MDL for this pollutant, as shown in Figure 4-20. The MDL and detection rate of this pollutant were discussed in the previous section. However, all four quarterly average concentrations for SPAZ are greater than the MDL. In addition, three of the four quarterly average concentrations for PXSS are also greater than the MDL. The only other site for which a quarterly average concentration of *p*-dichlorobenzene was greater than the MDL is for TMOK's third quarter average.
- As shown in Figure 4-21, most of the quarterly average concentrations for NMP sites measuring 1,2-dichloroethane are similar to the MDL for this pollutant. The exceptions to this are all for the Calvert City sites.
- Most of the quarterly average concentrations of ethylbenzene are less than 0.75 µg/m³, as shown in Figures 4-22a and 4-22b. Exceptions to this include first and fourth quarter average concentrations for ANAK, PXSS, and SPAZ. In addition, all of the quarterly average concentrations of ethylbenzene for KMMS

are greater than $0.75 \mu\text{g}/\text{m}^3$. Quarterly averages calculated for KMMS range from $0.85 \mu\text{g}/\text{m}^3$ for the fourth quarter of 2013 to $3.35 \mu\text{g}/\text{m}^3$ for the second quarter of 2013.

- Figure 4-23 is the quarterly average concentration graph for formaldehyde. This figure shows that most of the quarterly average concentrations are less than $6 \mu\text{g}/\text{m}^3$. With the exception of BTUT's first quarter average concentration, the only quarterly averages greater than $6 \mu\text{g}/\text{m}^3$ are second and/or third quarter averages. Similarly, all but four of the 23 quarterly averages greater than $4 \mu\text{g}/\text{m}^3$ were calculated for the second or third quarter. Only GPCO and BTUT have quarterly average concentrations greater than $10 \mu\text{g}/\text{m}^3$, the first quarter for BTUT and the second quarter for GPCO.
- All of the quarterly average concentrations of hexachloro-1,3-butadiene are roughly equal to or less than $0.05 \mu\text{g}/\text{m}^3$. However, the MDL for this pollutant is $0.304 \mu\text{g}/\text{m}^3$. As discussed previously, the detection rate for this pollutant is relatively low. Of note, the fourth quarter averages, where they could be calculated, were most often the highest quarterly average for sites where all four are available. Of the 30 sites with four quarterly averages of hexachloro-1,3-butadiene in Figure 4-24, the fourth quarter average concentration is the maximum quarterly average for 26 of them.
- Figure 4-25 for naphthalene shows that there is considerable variability in the quarterly average concentrations calculated for NBIL. Quarterly average concentrations for this site range from $33.16 \text{ ng}/\text{m}^3$ for the fourth quarter of 2013 to $304.90 \text{ ng}/\text{m}^3$ for the second quarter of 2013. This graph also shows that naphthalene concentrations measured at CHSC, GLKY, and UNVT tended to be lower than many of the other NMP sites.
- Figures 4-26a and 4-26b show that concentrations of nickel tended to be highest at ASKY-M, SEWA, and TOOK. These are the only NMP sites sampling nickel with at least two quarterly average concentrations greater than $2 \text{ ng}/\text{m}^3$. All four quarterly averages of nickel are greater than $2 \text{ ng}/\text{m}^3$ for ASKY-M, three are greater than $2 \text{ ng}/\text{m}^3$ for TOOK (all but the fourth quarter of 2014), and two are greater than $2 \text{ ng}/\text{m}^3$ for SEWA (second and third quarters only). The fourth quarter average for BTUT is also greater than $2 \text{ ng}/\text{m}^3$.

Graphing the data by method (TO-15 and SNMOC) or by particulate fraction (PM_{10} and TSP) may reveal other trends. Examples include the following:

- Figures 4-18a and 4-18b show that there can be a difference in detection rates between methods. 1,3-Butadiene was measured with both the TO-15 and SNMOC methods. Figure 4-18a presents the quarterly averages for sites sampling VOCs with Method TO-15 and Figure 4-18b presents the quarterly averages for sites sampling using the SNMOC method. Most sites sampling 1,3-butadiene with Method TO-15 detected this pollutant year-round. With those sampling with the SNMOC method, this is harder to determine. Figure 4-18b has fewer bars on it. In

some cases, such as the second and third quarter of 2013 for BMCO, this compound was not detected; thus, the quarterly average for this site is zero. In other cases, such as the first quarter for BMCO, the site does not meet the valid sample criteria and thus, no quarterly average was calculated. The MDLs between the two methods are quite different ($0.024 \mu\text{g}/\text{m}^3$ for TO-15 and $0.104 \mu\text{g}/\text{m}^3$ for SNMOC).

- Splitting the metals graphs based on particulate fraction isolates the Oklahoma sites from sites in other states. For both arsenic and nickel, the Tulsa sites tended to have higher concentrations of these pollutants than the Oklahoma City sites.

Figure 4-14. Comparison of Average Quarterly Acenaphthene Concentrations

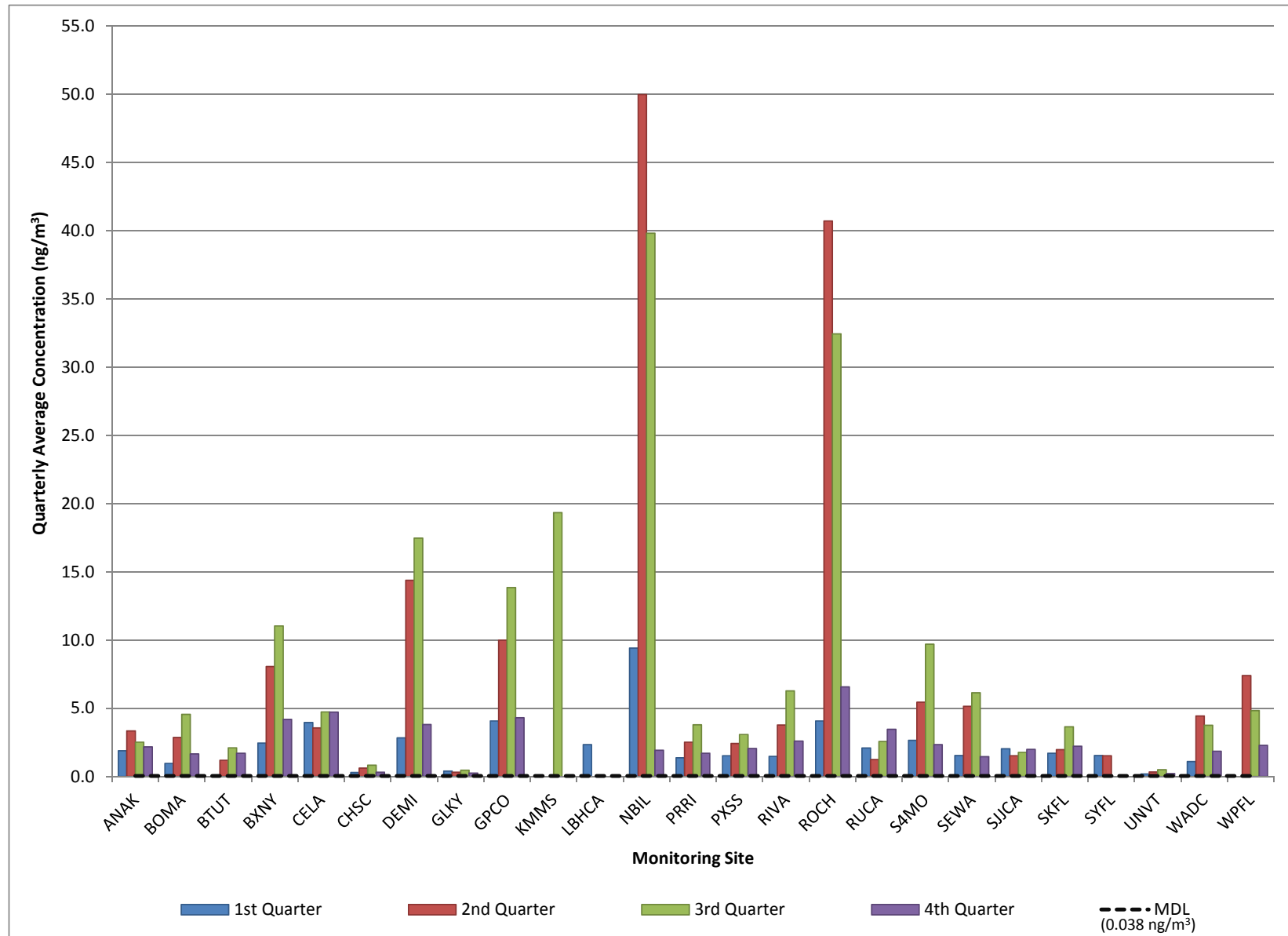


Figure 4-15. Comparison of Average Quarterly Acetaldehyde Concentrations

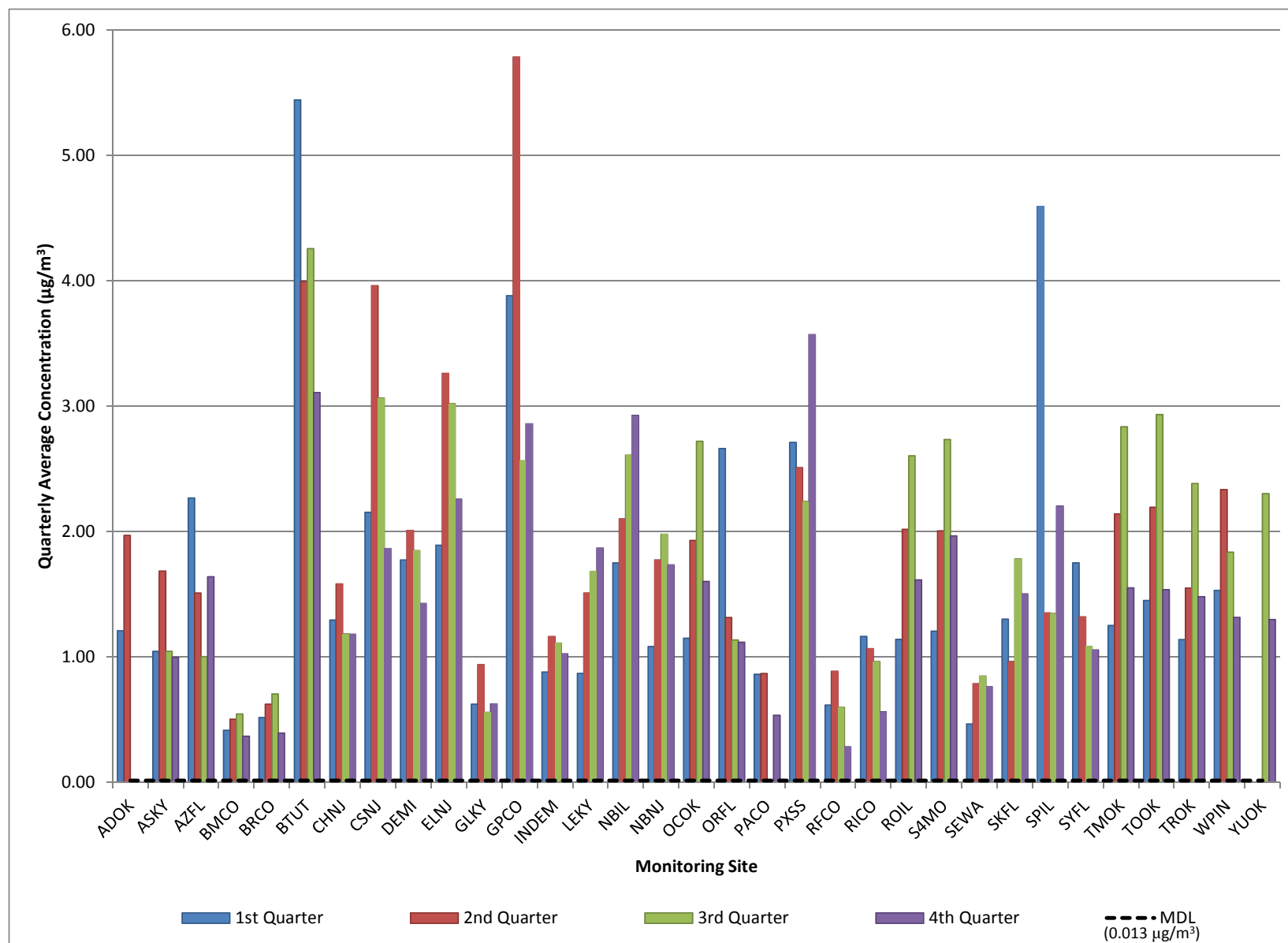


Figure 4-16a. Comparison of Average Quarterly Arsenic (PM₁₀) Concentrations

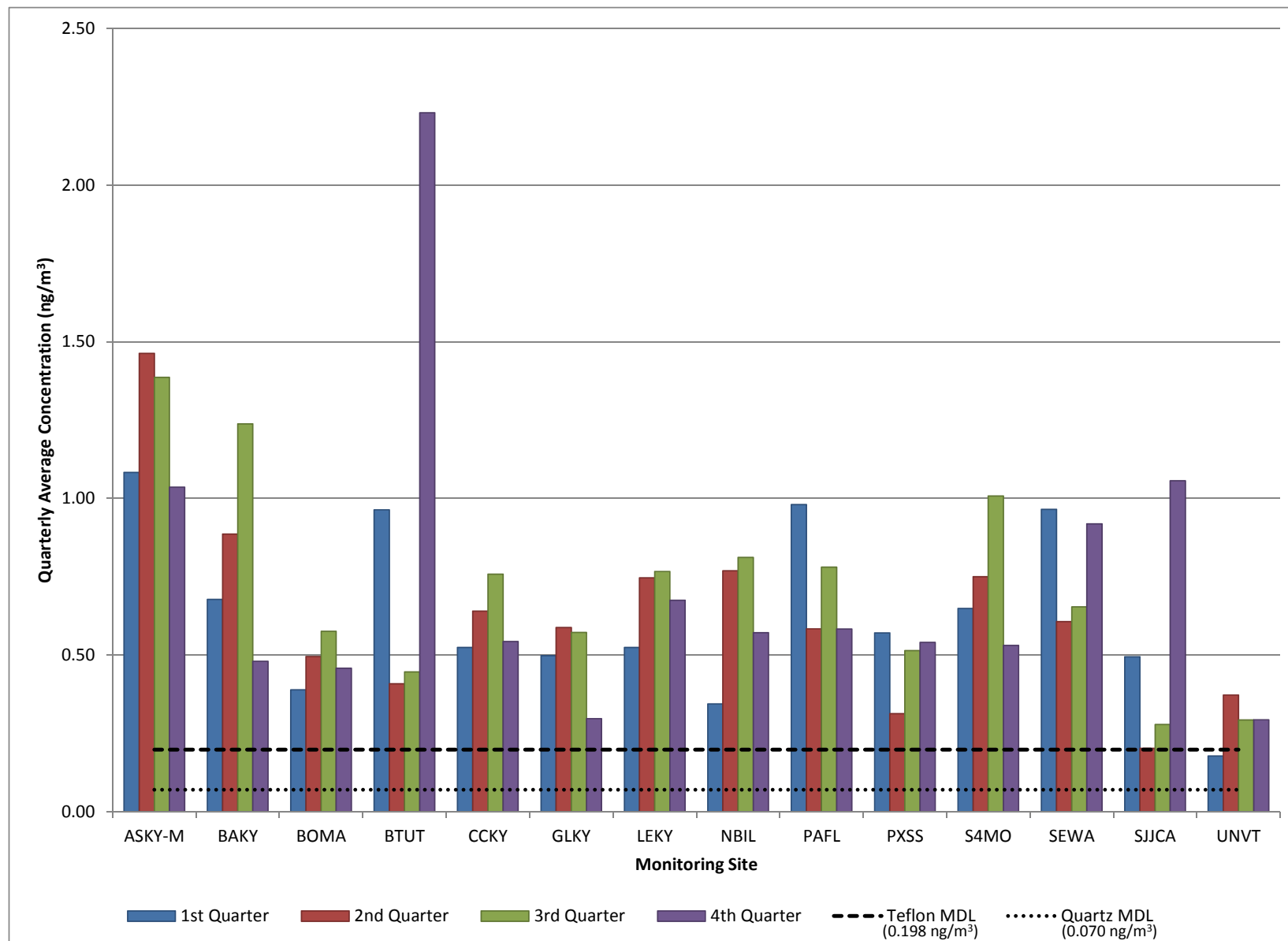


Figure 4-16b. Comparison of Average Quarterly Arsenic (TSP) Concentrations

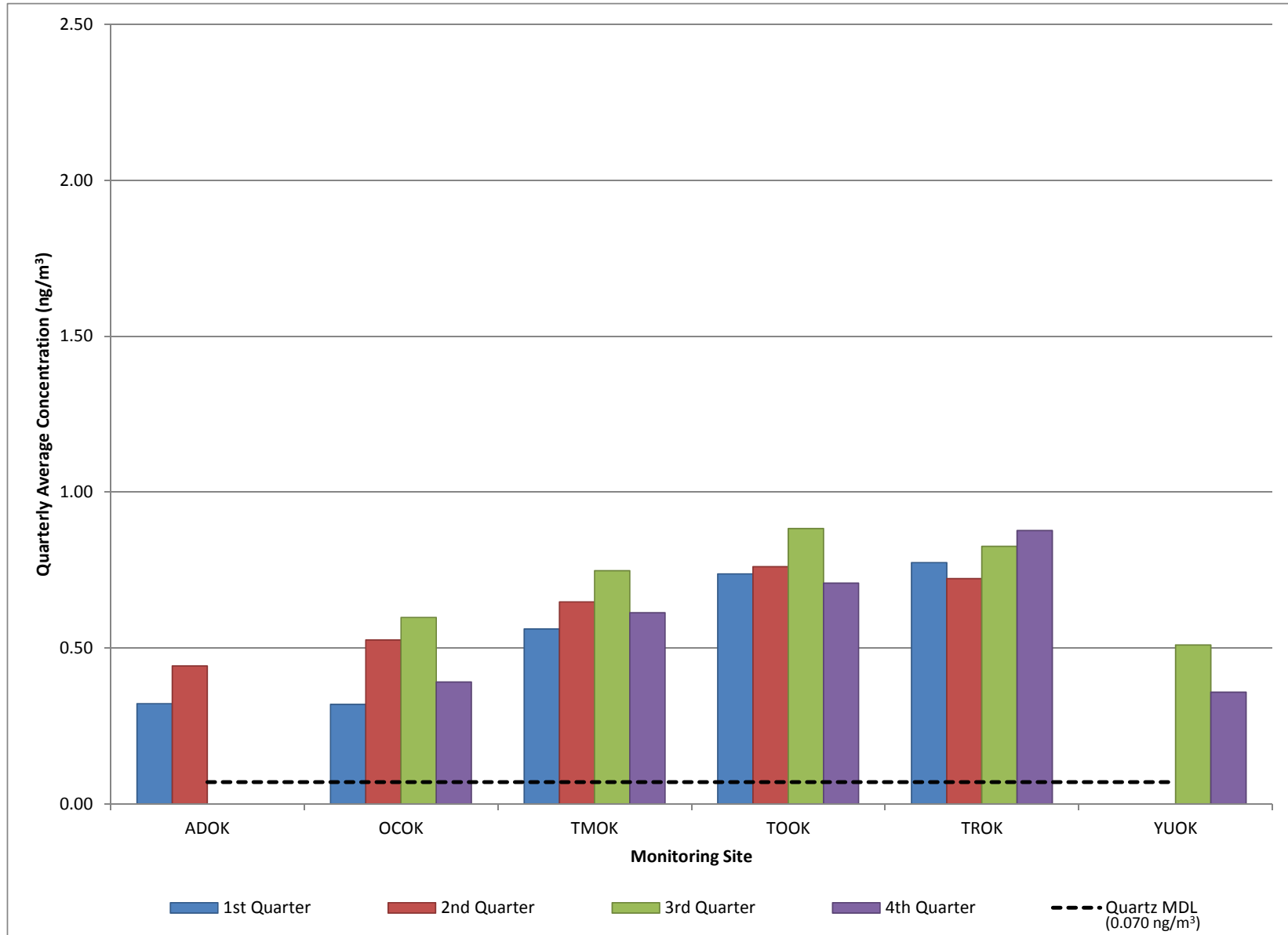


Figure 4-17a. Comparison of Average Quarterly Benzene (Method TO-15) Concentrations

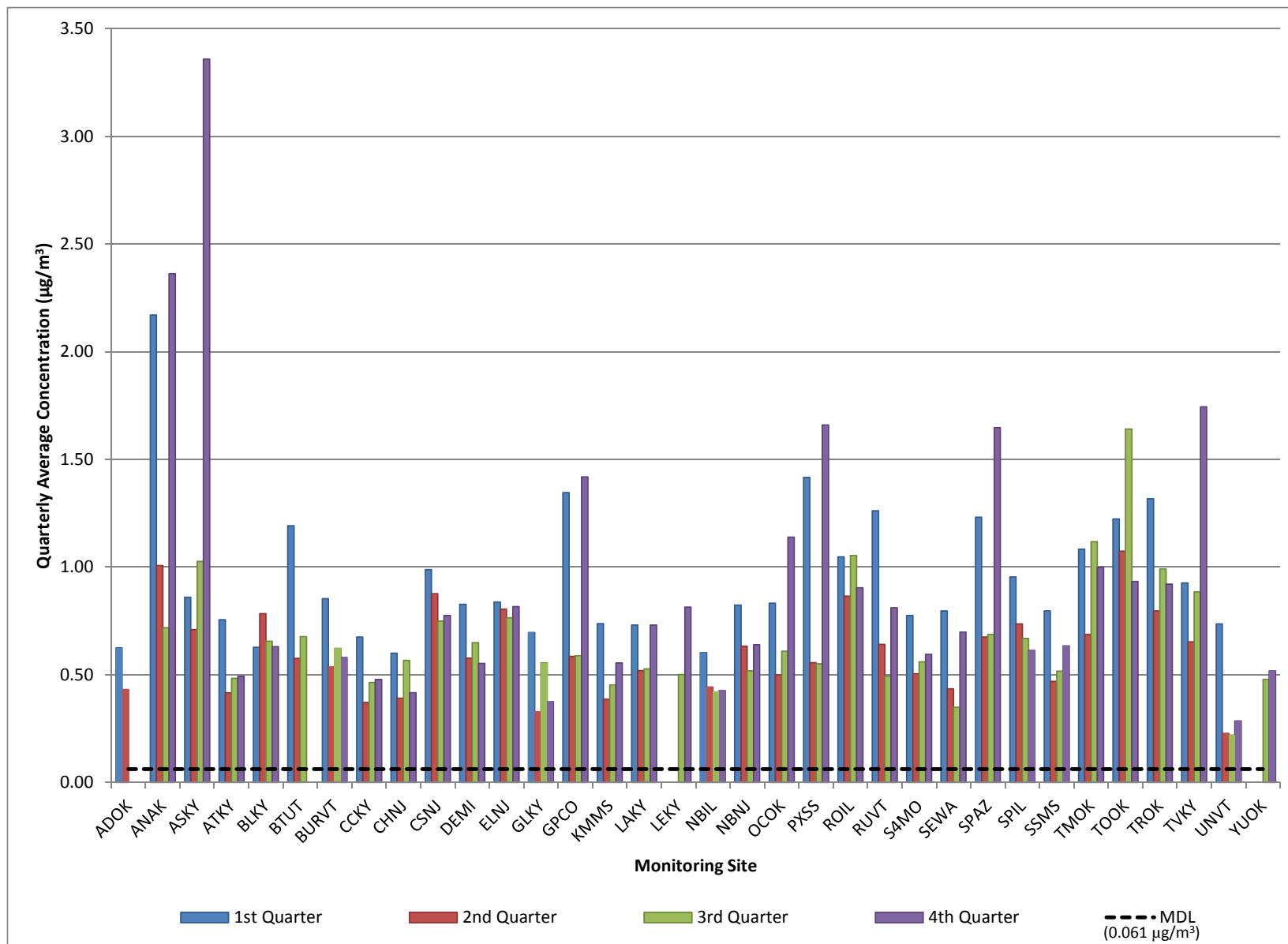


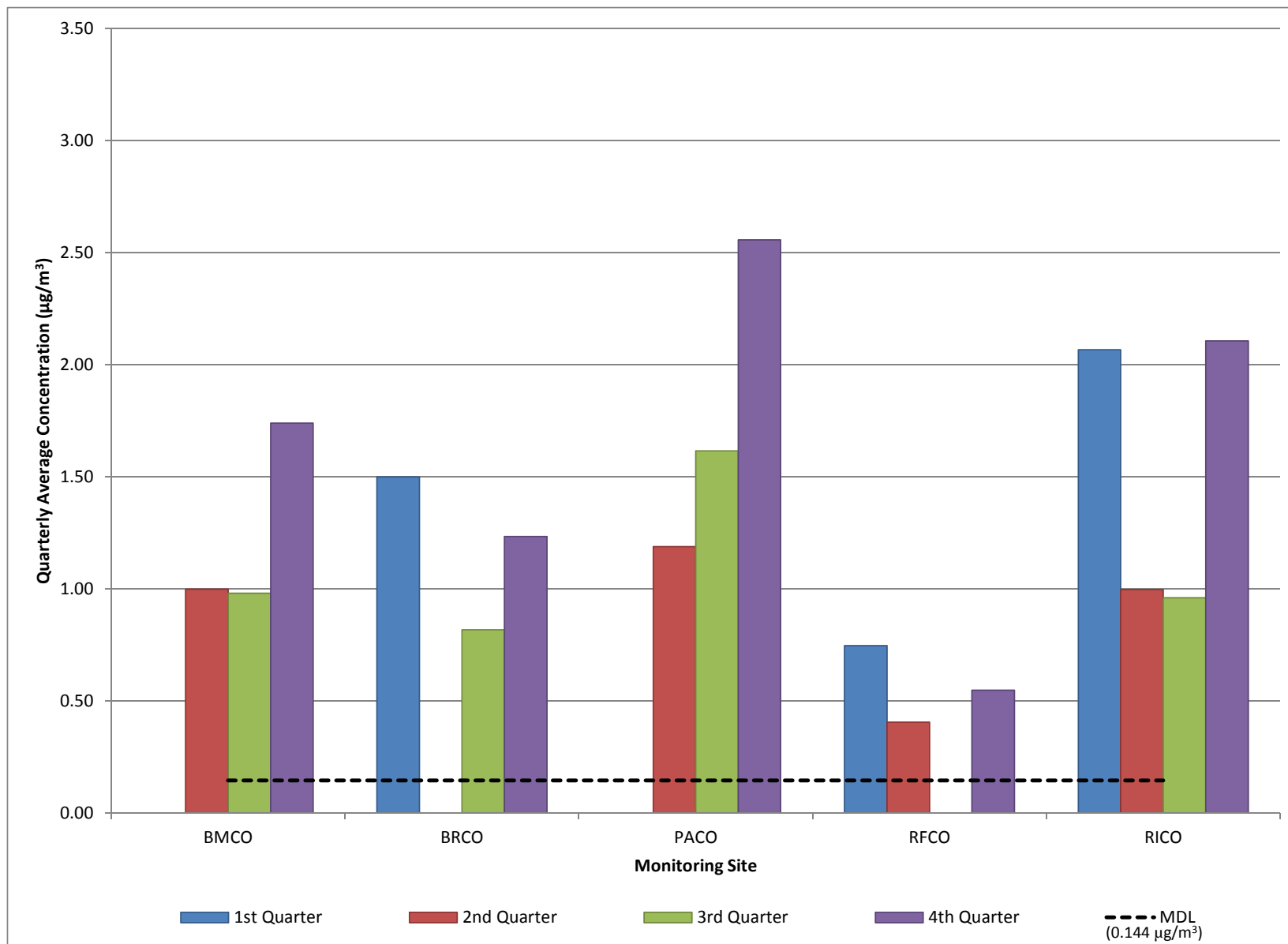
Figure 4-17b. Comparison of Average Quarterly Benzene (SNMOC) Concentrations

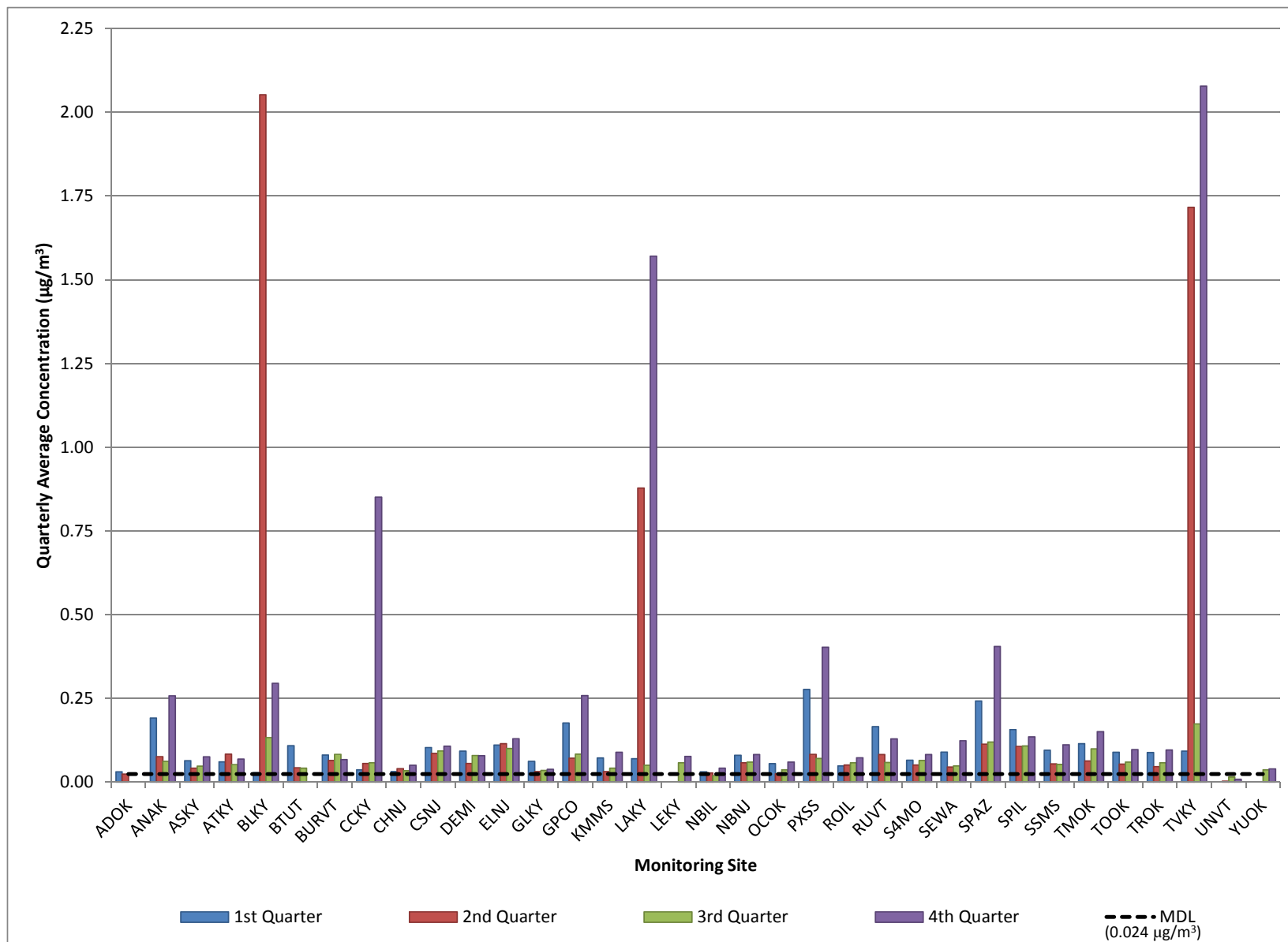
Figure 4-18a. Comparison of Average Quarterly 1,3-Butadiene (Method TO-15) Concentrations

Figure 4-18b. Comparison of Average Quarterly 1,3-Butadiene (SNMOC) Concentrations

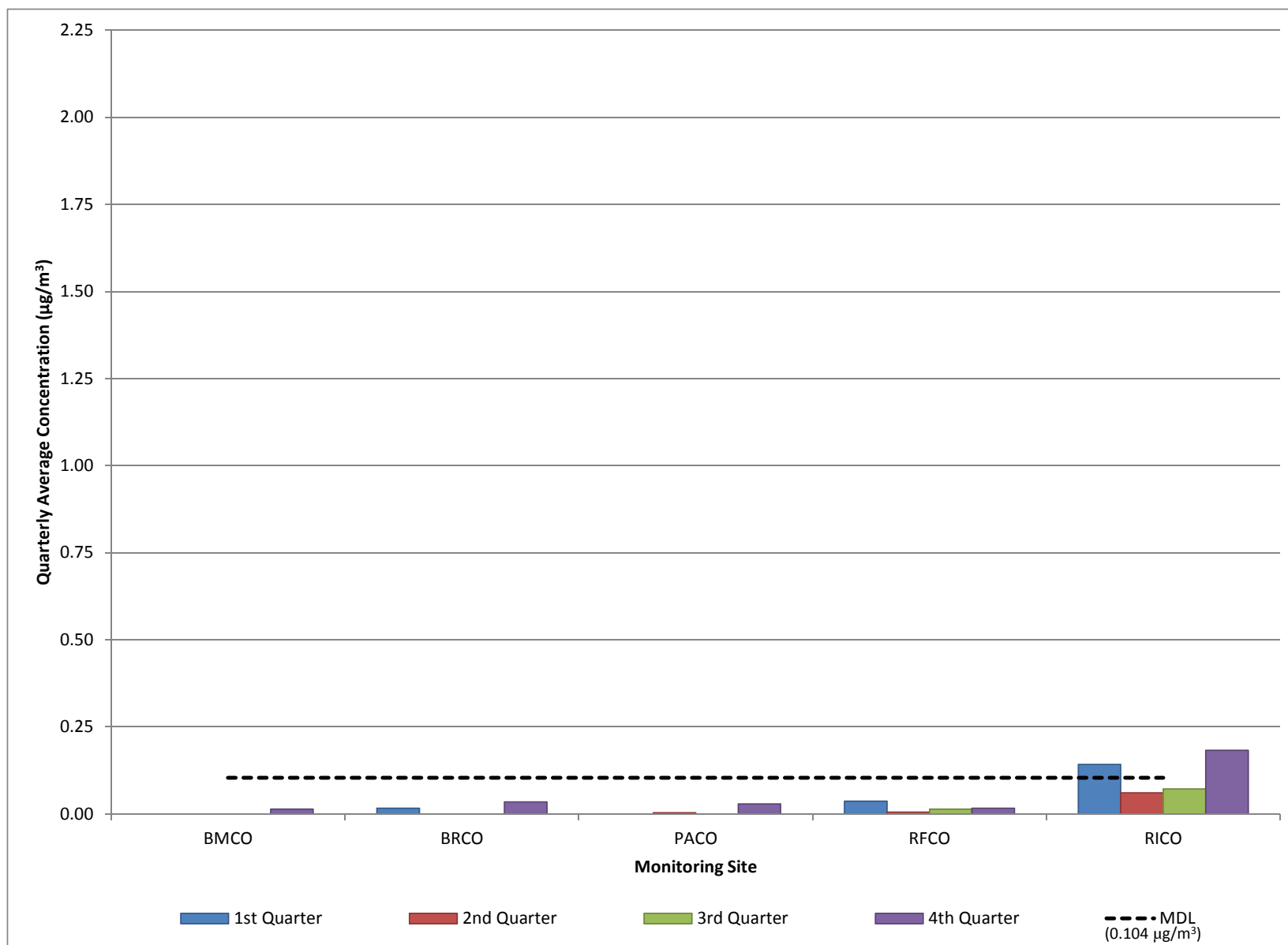


Figure 4-19. Comparison of Average Quarterly Carbon Tetrachloride Concentrations

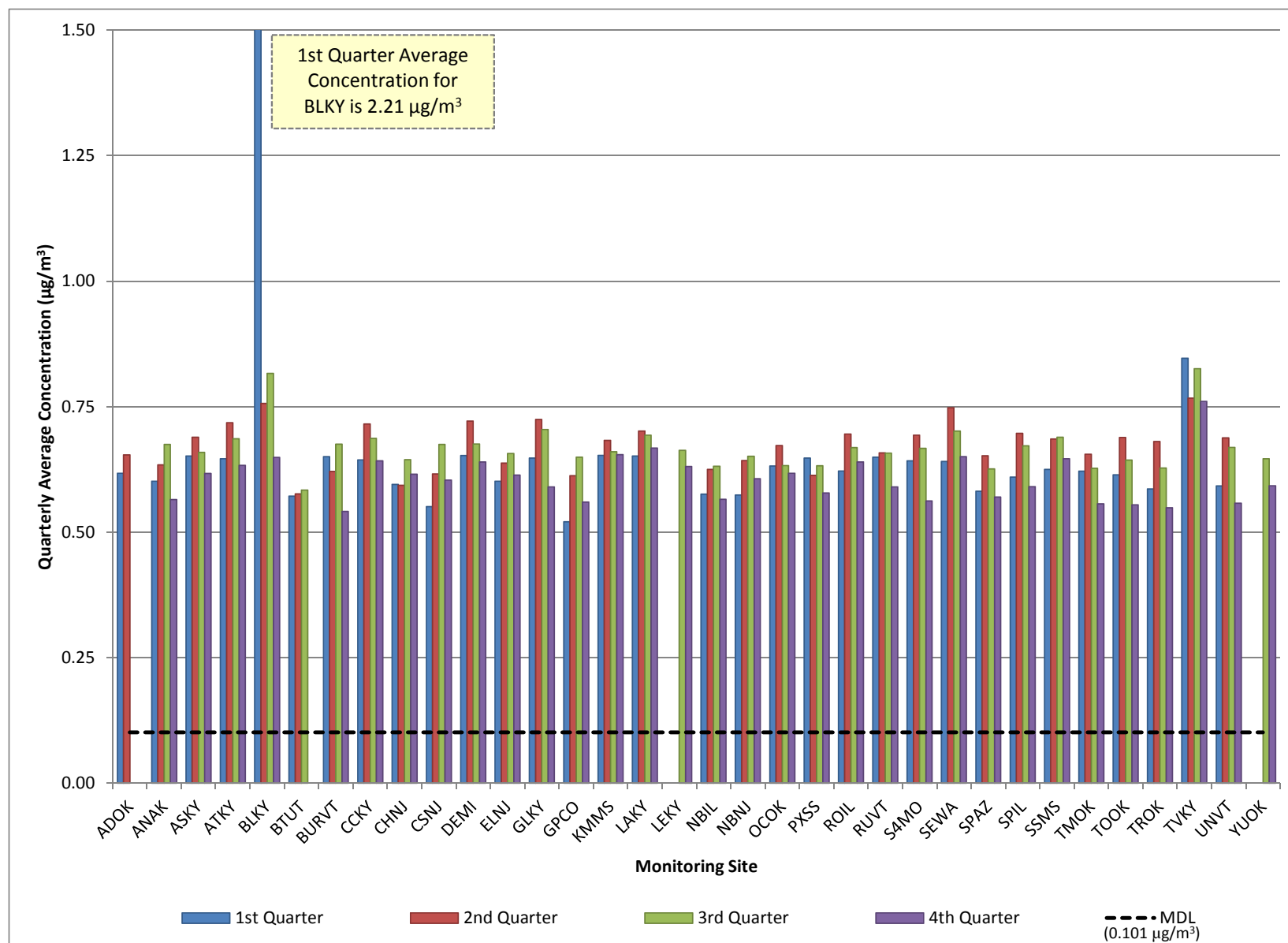


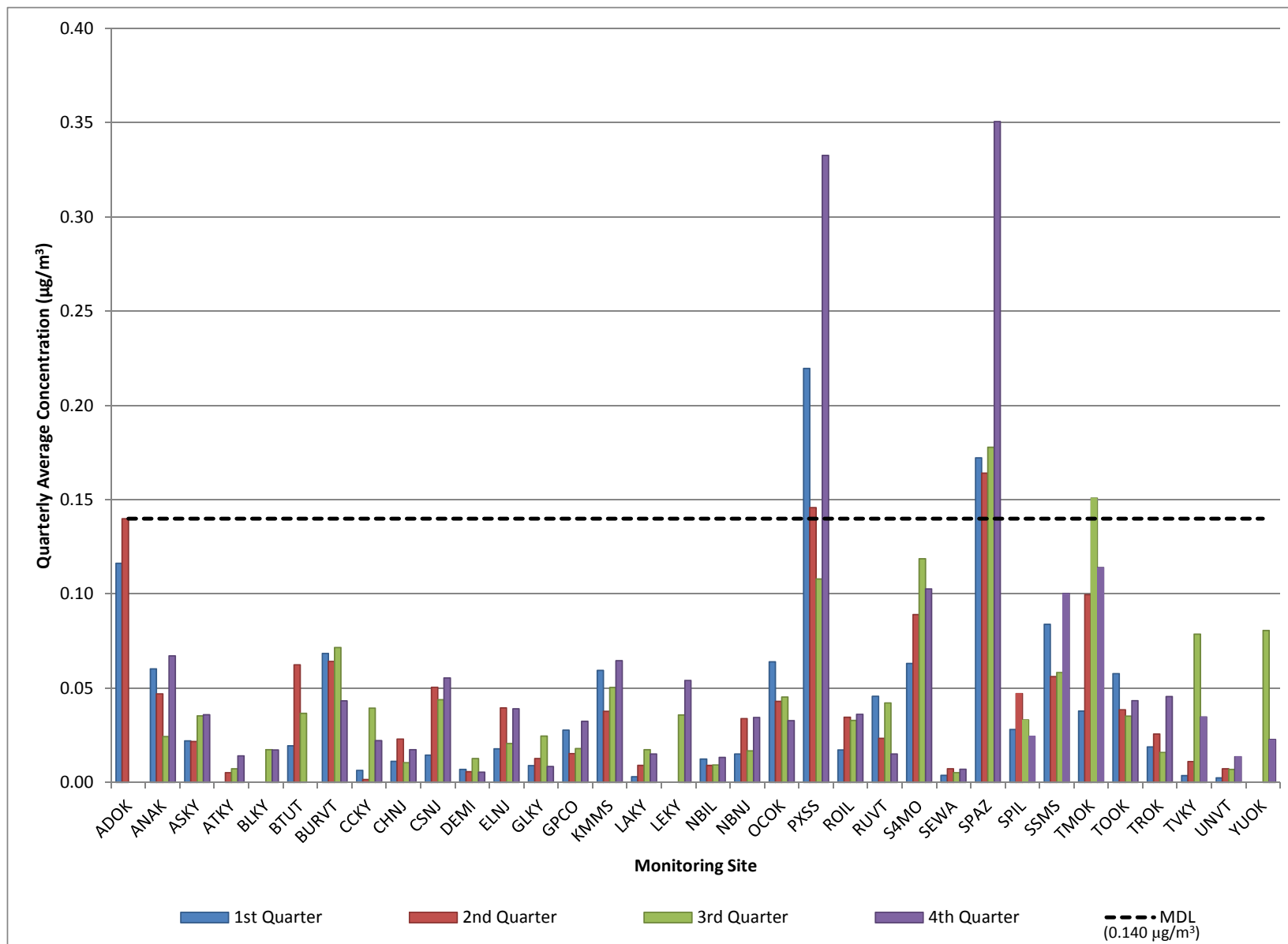
Figure 4-20. Comparison of Average Quarterly *p*-Dichlorobenzene Concentrations

Figure 4-21. Comparison of Average Quarterly 1,2-Dichloroethane Concentrations

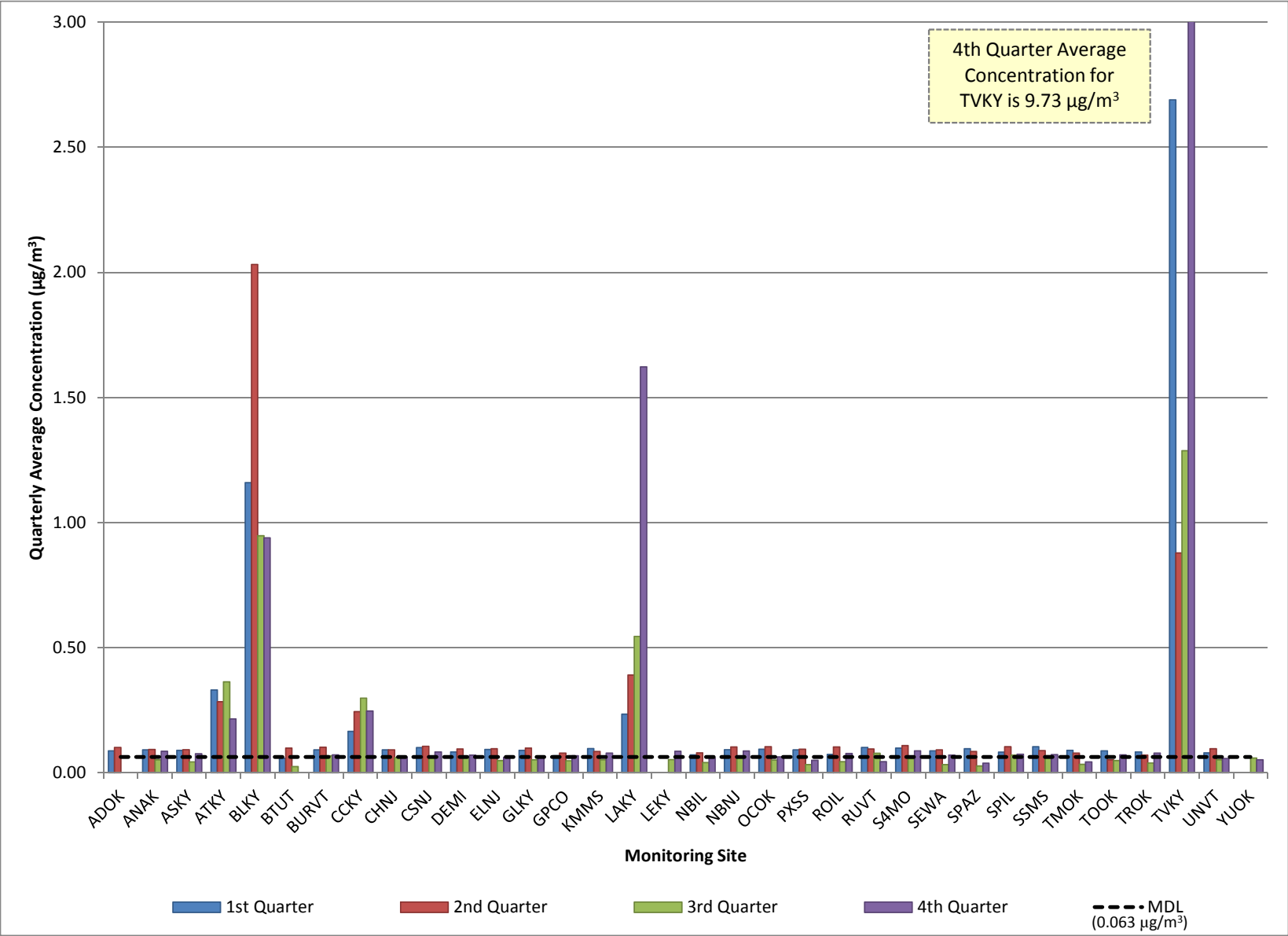


Figure 4-22a. Comparison of Average Quarterly Ethylbenzene (Method TO-15) Concentrations

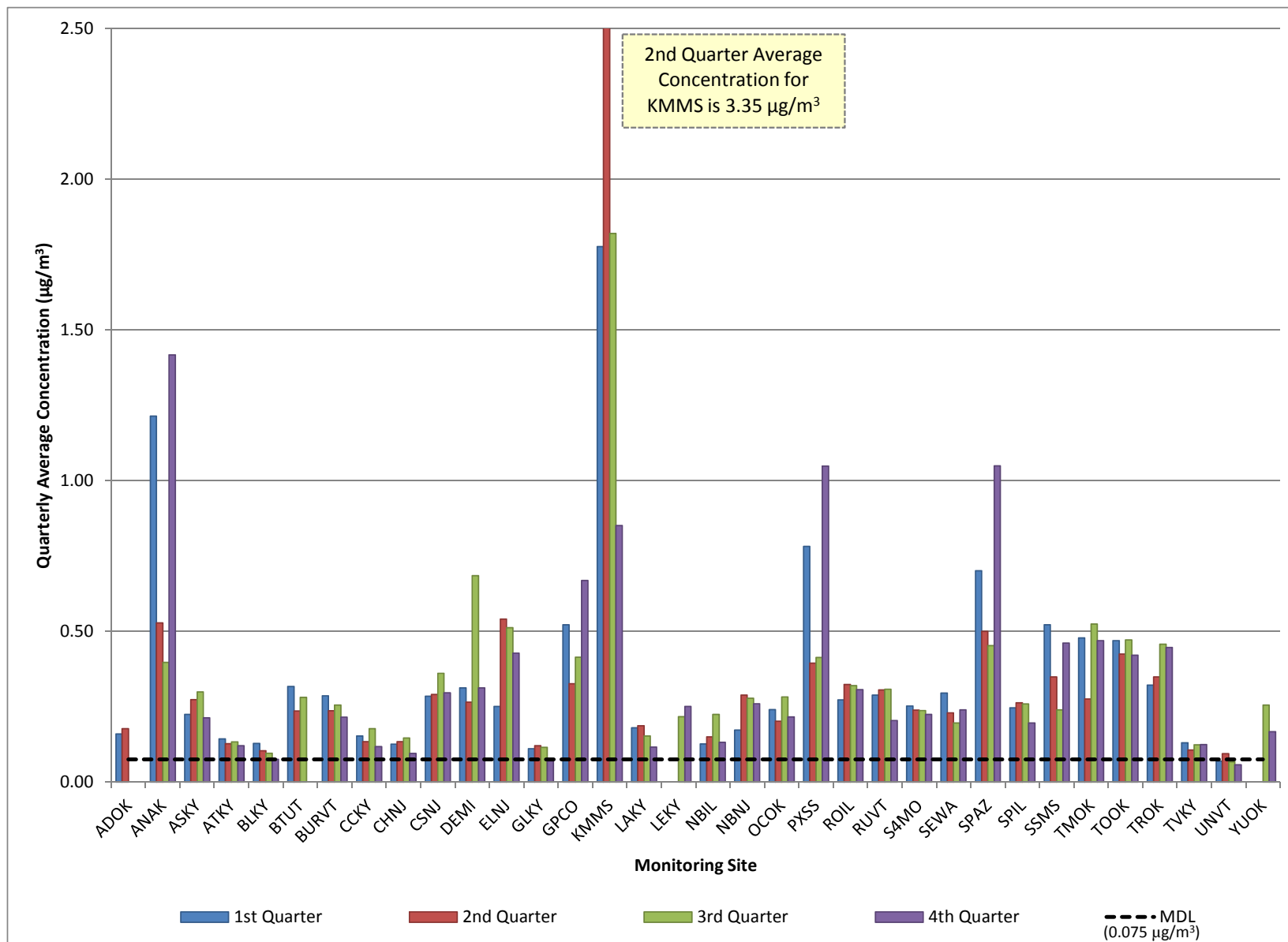


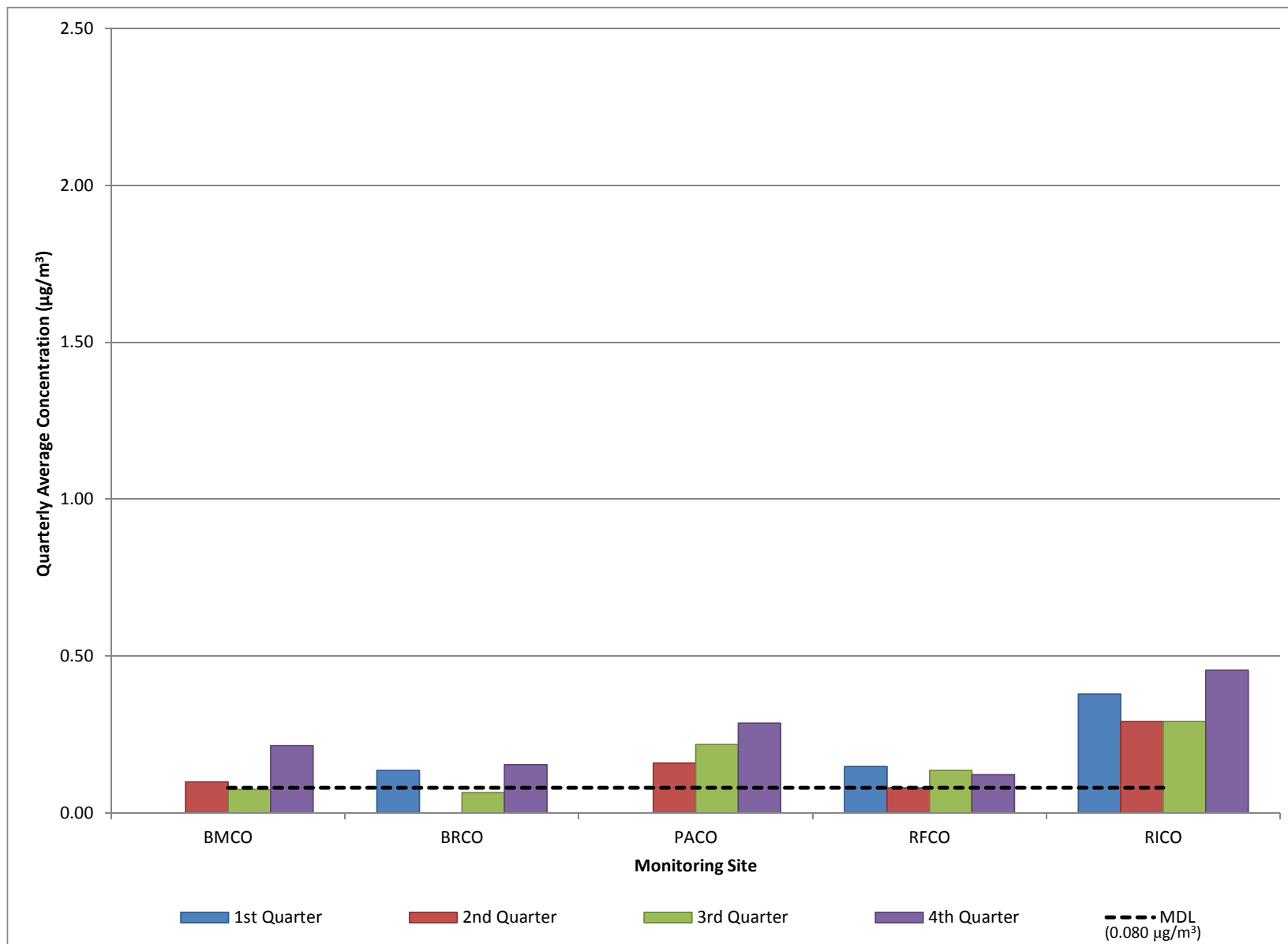
Figure 4-22b. Comparison of Average Quarterly Ethylbenzene (SNMOC) Concentrations

Figure 4-23. Comparison of Average Quarterly Formaldehyde Concentrations

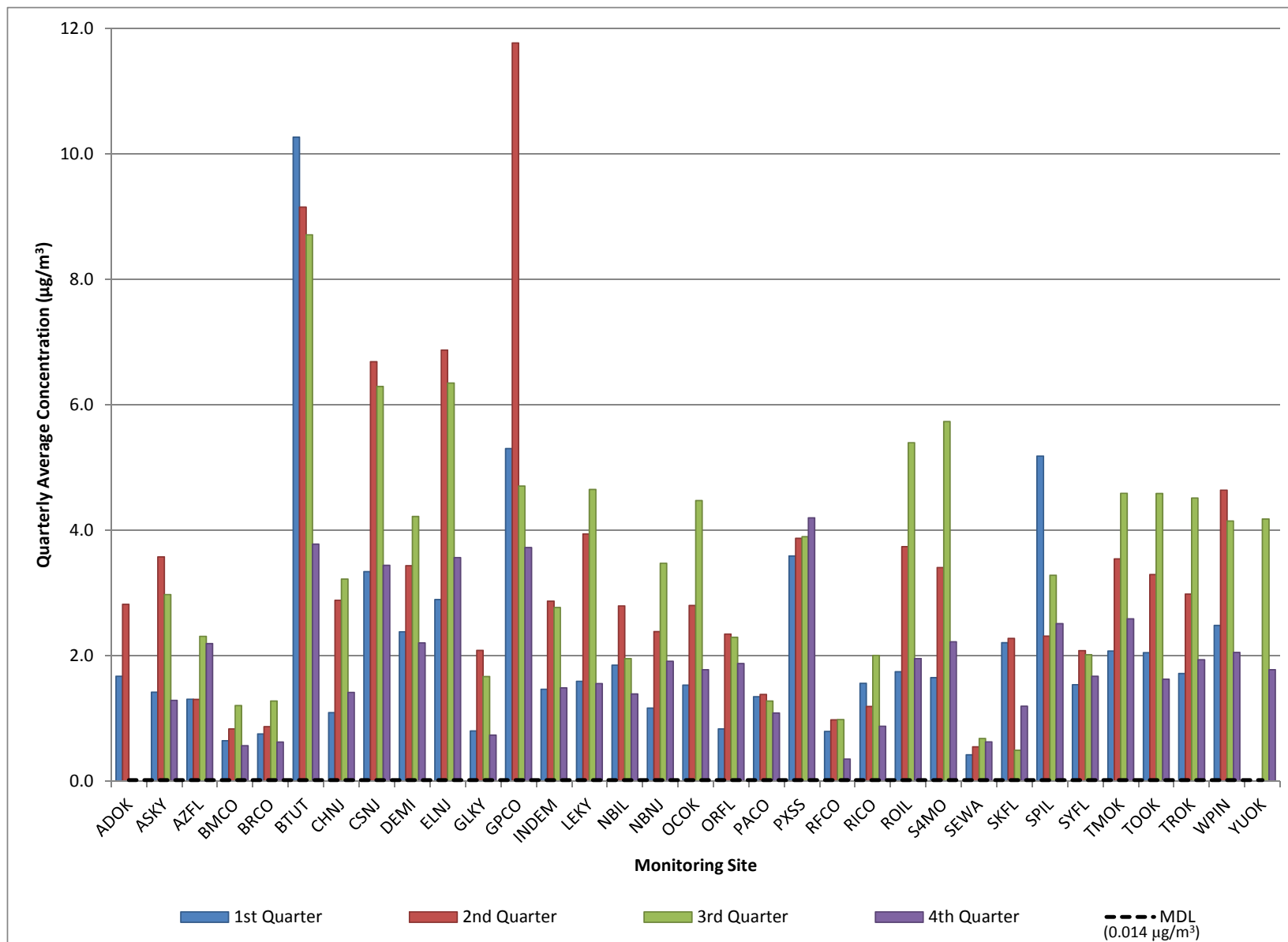


Figure 4-24. Comparison of Average Quarterly Hexachloro-1,3-Butadiene Concentrations

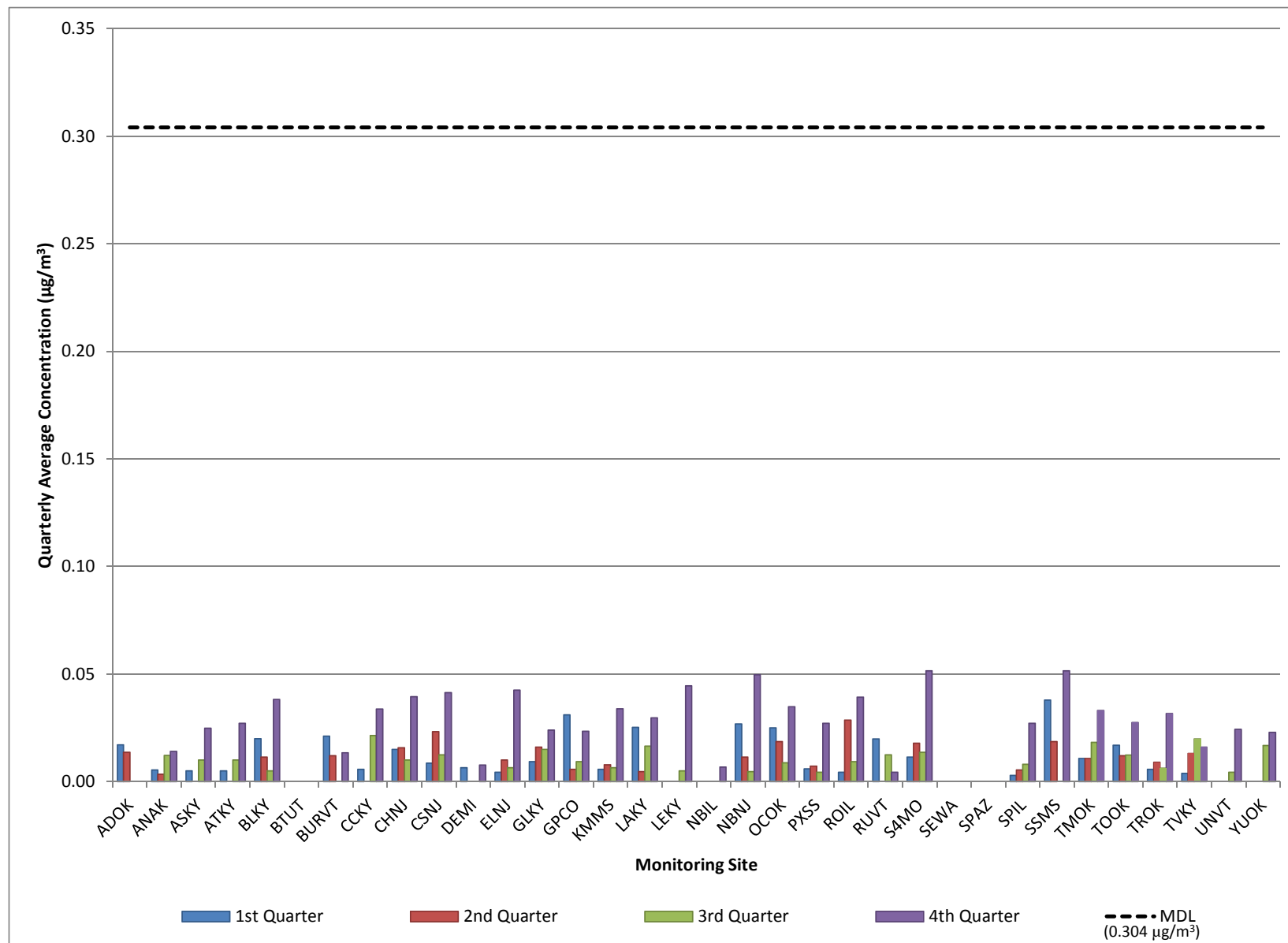


Figure 4-25. Comparison of Average Quarterly Naphthalene Concentrations

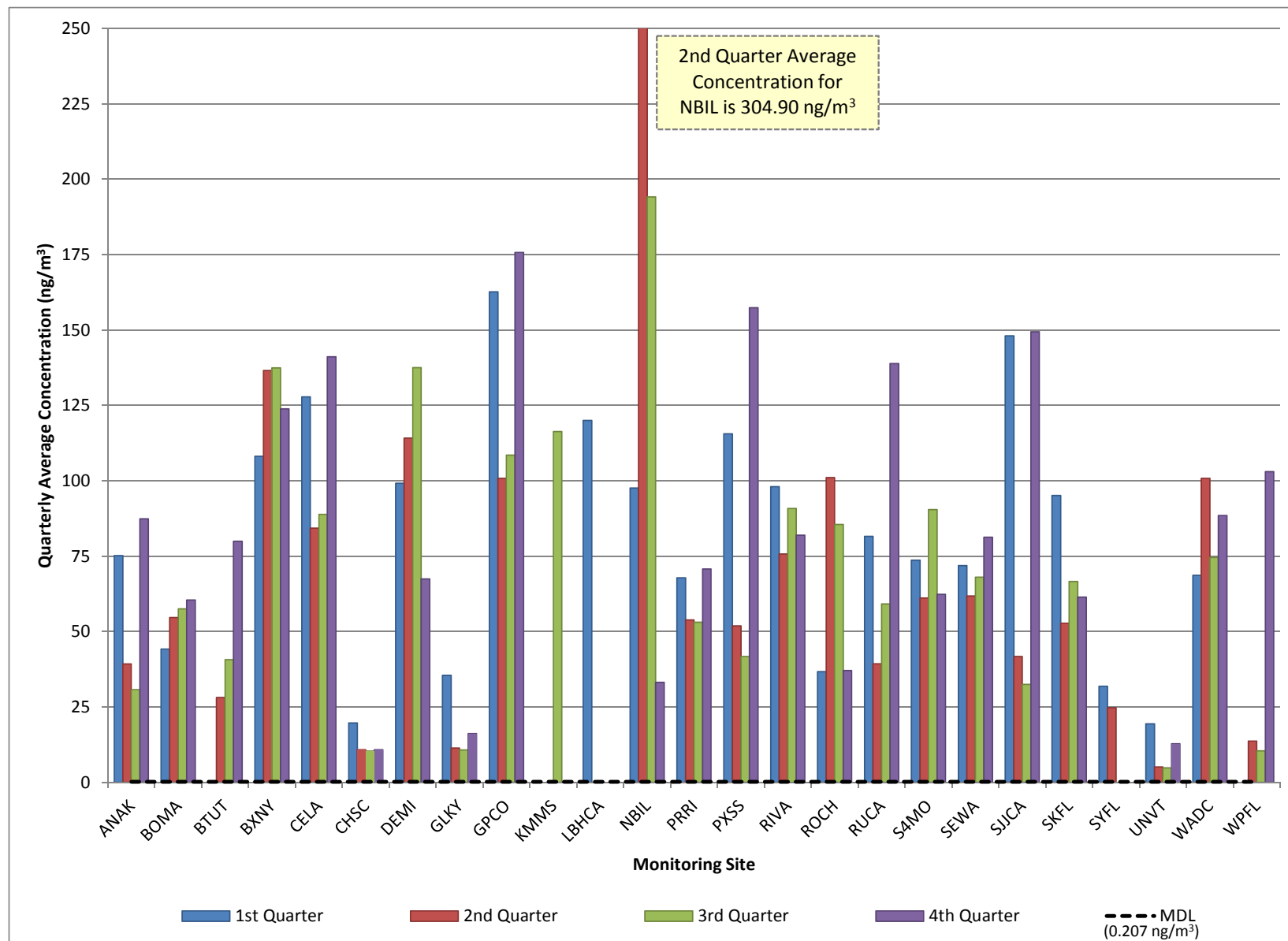


Figure 4-26a. Comparison of Average Quarterly Nickel (PM₁₀) Concentrations

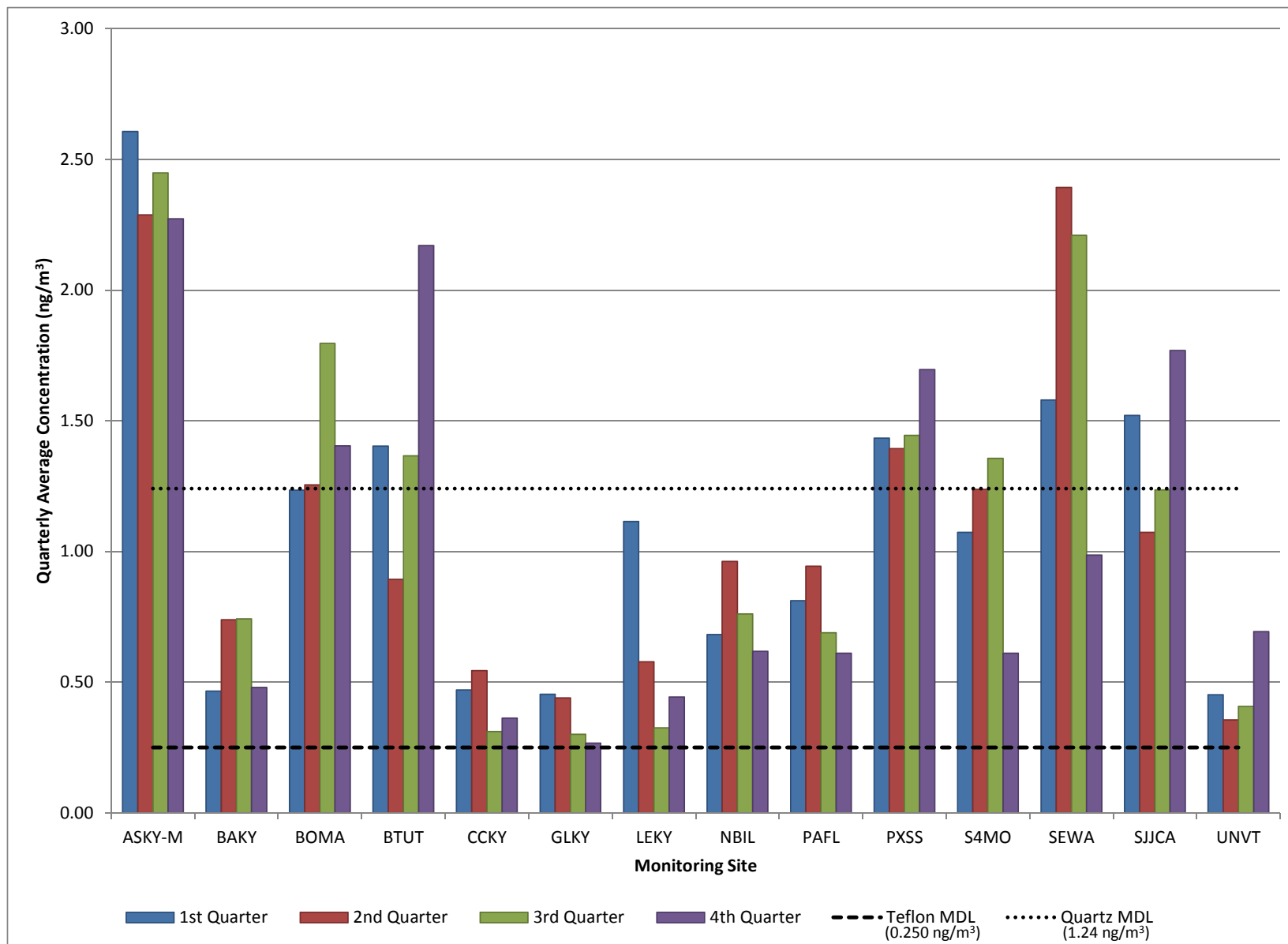
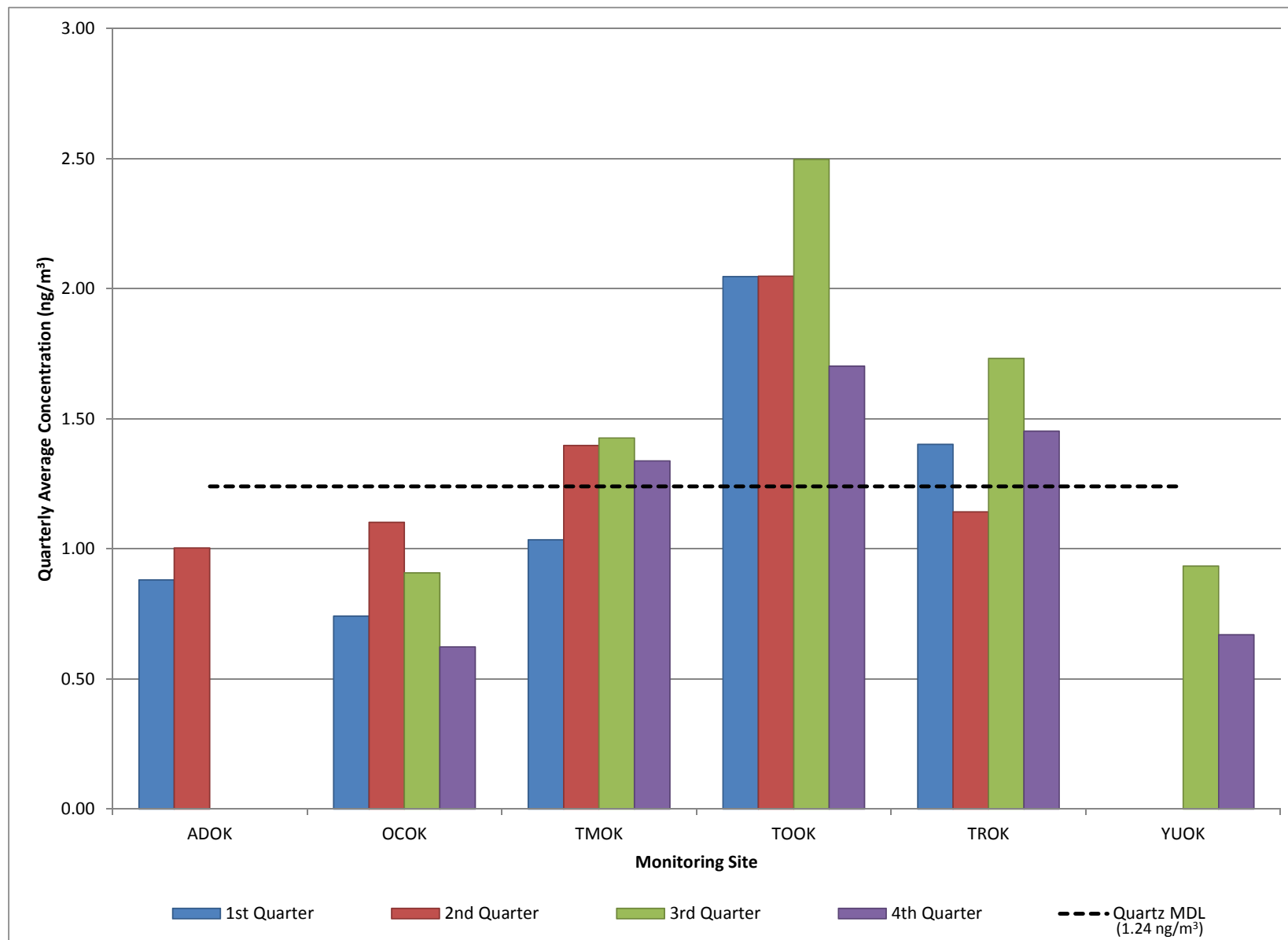


Figure 4-26b. Comparison of Average Quarterly Nickel (TSP) Concentrations

4.5 Greenhouse Gases from Method TO-15

Table 4-14 presents the program-level average concentrations for the 11 GHGs measured using Method TO-15, in descending order by GWP. Also included in Table 4-14 is the alternate name or acronym of each pollutant, where applicable. As shown, most of the GHGs were detected frequently. The detection rate ranged from 73 percent to 100 percent, with only chloroform, bromomethane, 1,2-dichloroethane, and 1,1,1-trichloroethane detected in less than 95 percent of VOC samples collected (out of a total 1,883 valid VOC samples).

Dichlorodifluoromethane (CFC-12) and dichlorotetrafluoroethane (CFC-114) have the highest GWPs of the GHGs measured by Method TO-15 (10,200 and 8,590, respectively), while bromomethane and 1,2-dichloroethane have the lowest GWPs (2 and <1, respectively). The GWP for 1,2-dichloroethane is new for this report.

Dichloromethane has the highest program-level average concentration among the GHGs measured ($8.17 \pm 6.51 \mu\text{g}/\text{m}^3$), although this average concentration is influenced by outliers, as indicated by the confidence interval. A review of the data shows that three concentrations greater than $1,000 \mu\text{g}/\text{m}^3$ were measured at BTUT; eight additional concentrations greater than $100 \mu\text{g}/\text{m}^3$ were also measured at this site. Dichloromethane concentrations greater than $50 \mu\text{g}/\text{m}^3$ were also measured at NBIL, DEMI, and GPCO. However, the median concentration of this pollutant is less than $0.5 \mu\text{g}/\text{m}^3$, indicating that these high concentrations are the exception rather than the rule.

Dichlorodifluoromethane, trichlorofluoromethane, and chloromethane are the only other pollutants with program-level average concentrations greater than $1.0 \mu\text{g}/\text{m}^3$. With the exception of chloroform and 1,2-dichloroethane, the confidence intervals for the remaining pollutants are relatively small, indicating little variability in the measurements of these pollutants. The variability in the chloroform concentration is primarily due to a few high concentrations measured at NBIL (five concentrations ranging from $3.40 \mu\text{g}/\text{m}^3$ to $94.9 \mu\text{g}/\text{m}^3$) and BLKY (one concentration of $29.0 \mu\text{g}/\text{m}^3$). All but 21 chloroform concentrations (out of 1,883) measured across the program are less than $1 \mu\text{g}/\text{m}^3$. The variability in the 1,2-dichloroethane measurements was discussed in Section 4.2 and is attributable to measurements collected at the Calvert City, Kentucky sites.

Table 4-14. Greenhouse Gases Measured by Method TO-15

Pollutant	Alternate Name or Acronym	Global Warming Potential ¹ (100 yrs)	Total # of Measured Detections ²	2013 Program Average (µg/m ³)
Dichlorodifluoromethane	CFC-12	10,200	1,883	2.52 ± 0.02
Dichlorotetrafluoroethane	CFC-114	8,590	1,882	0.12 ± <0.01
Trichlorotrifluoroethane	CFC-113	5,820	1,882	0.64 ± <0.01
Trichlorofluoromethane	CFC-11	4,660	1,883	1.48 ± 0.02
Carbon Tetrachloride	--	1,730	1,882	0.66 ± 0.02
1,1,1-Trichloroethane	Methyl chloroform	160	1,365	0.04 ± <0.01
Chloroform	--	16	1,478	0.24 ± 0.11
Chloromethane	Methyl chloride	12	1,883	1.16 ± 0.01
Dichloromethane ³	Methylene chloride	9	1,791	8.17 ± 6.51
Bromomethane	Methyl bromide	2	1,404	0.05 ± 0.02
1,2-Dichloroethane	--	<1	1,605	0.26 ± 0.12

¹GWPs presented here are from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) (IPCC, 2014).

²Out of 1,883 valid samples

³The total number of concentrations is not equal to 1,883 due to co-elution.

5.0 Site in Alaska

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the CSATAM site in Alaska, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

5.1 Site Characterization

This section characterizes the monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The ANAK site is located in Anchorage, Alaska. Figure 5-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 5-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 5-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 5-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 5-1. Anchorage, Alaska (ANAK) Monitoring Site

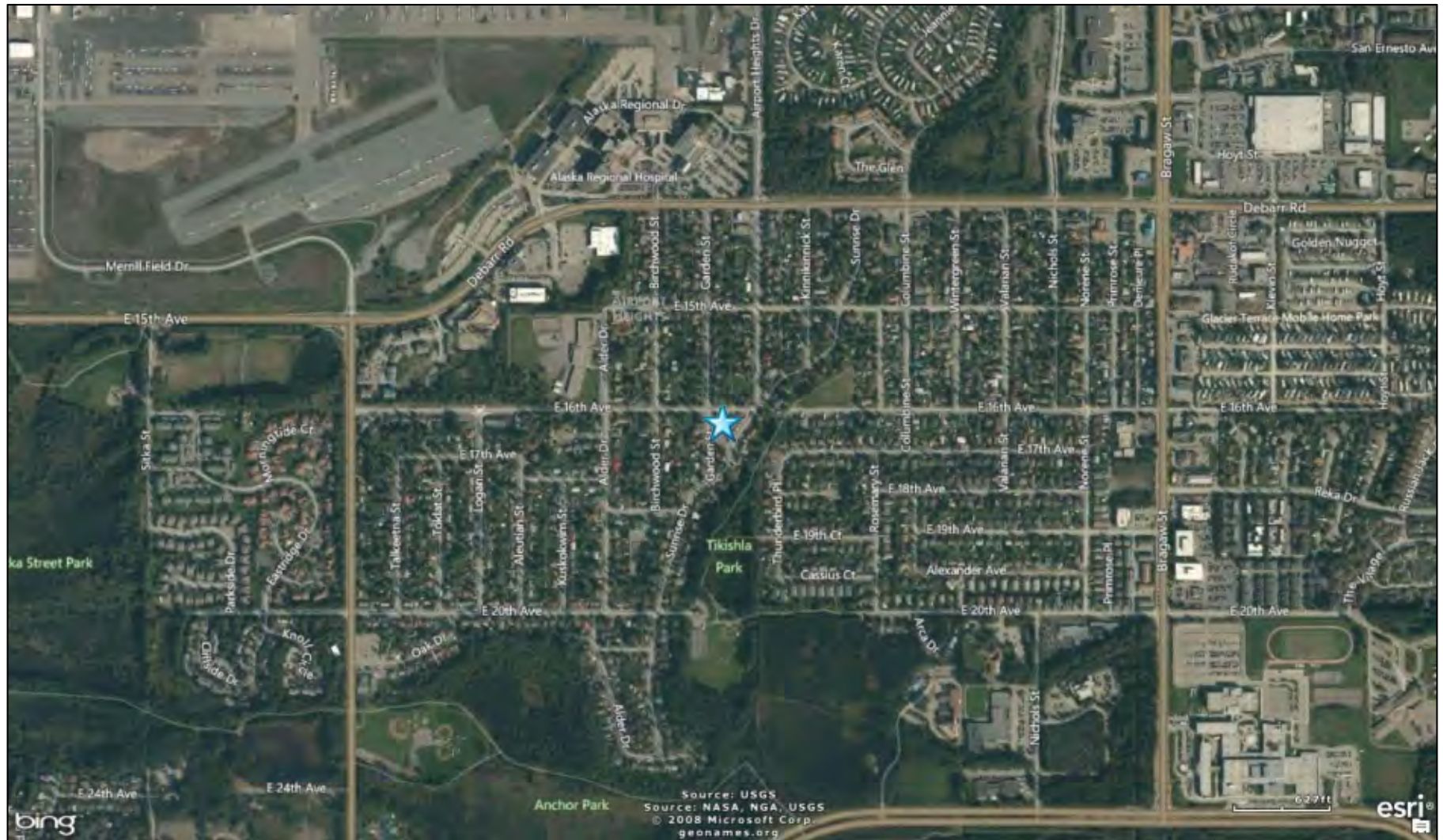


Figure 5-2. NEI Point Sources Located Within 10 Miles of ANAK

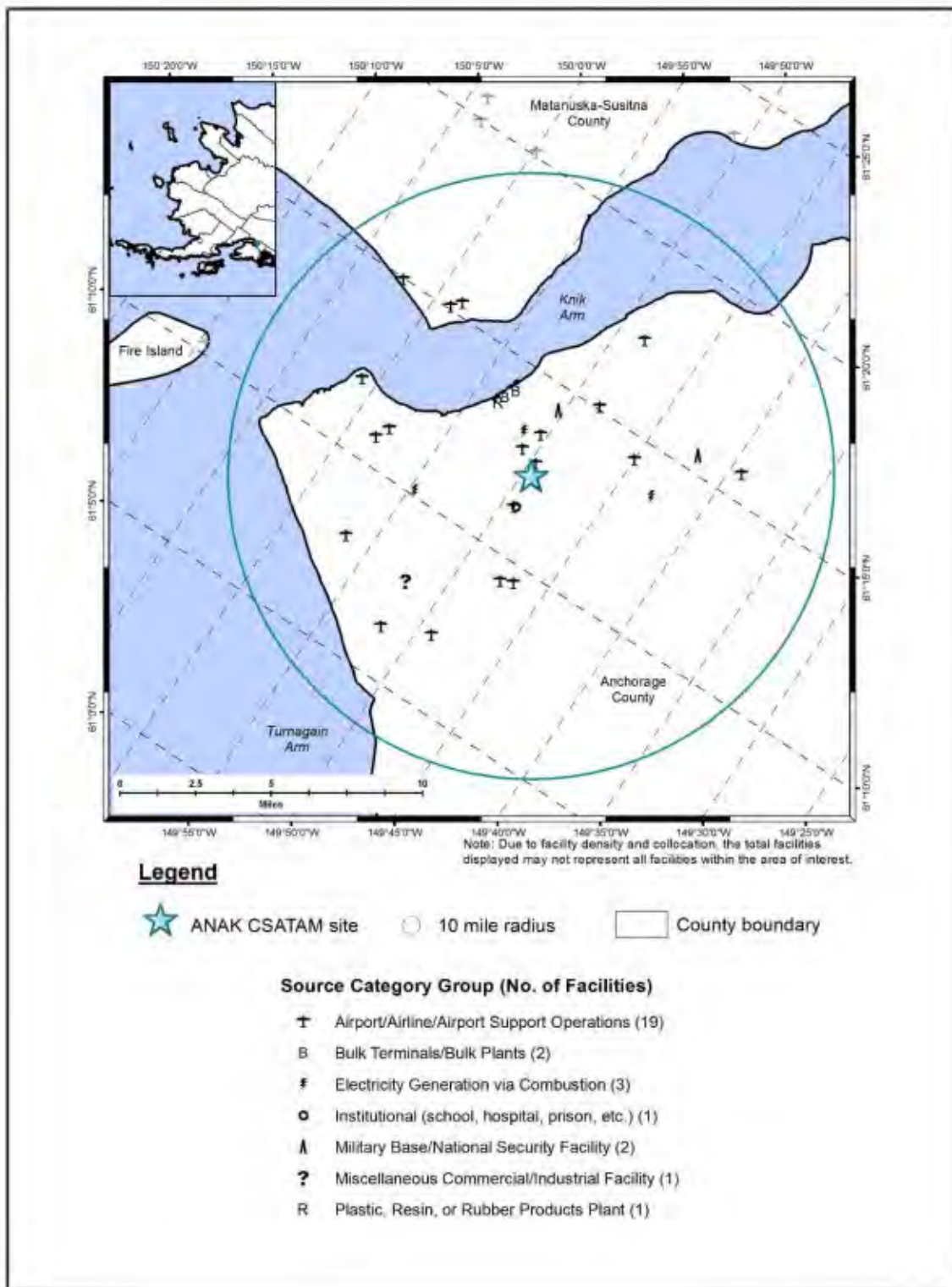


Table 5-1. Geographical Information for the Alaska Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
ANAK	02-020-0018	Anchorage	Anchorage	Anchorage, AK	61.205861, -149.824602	Residential	Suburban	CO, PM ₁₀ , PM _{2.5}

¹Data for additional pollutants are reported to AQS for ANAK (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

Anchorage is located near the end of the Cook Inlet, on the landmass between the Knik Arm and the Turnagain Arm. The city is surrounded primarily by mountains, including several national parks. The monitoring site is located in the north-central portion of the city, on the roof of Trinity Christian Reformed Church, off 16th Avenue. Figure 5-1 shows that residential subdivisions surround the monitoring site. Merrill Field Airport and the Alaska Regional Hospital are located just north of Debarr Road, both of which are shown in the top-left corner of Figure 5-1.

Figure 5-2 shows that the monitoring site is located in close proximity to a number of emissions sources. The source category with the greatest number of emissions sources near ANAK is the airport/airline/airport support operations category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. Other nearby emissions sources include bulk terminals and bulk plants, facilities generating electricity via combustion, institutions (which include schools, prisons, and/or hospitals), military bases, and a plastic, resin, or rubber product plant. The closest sources to ANAK are both in the “airport” category: the heliport at the Alaska Regional Hospital and Merrill Field Airport.

Table 5-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Alaska monitoring site. Table 5-2 includes both county-level population and vehicle registration information. Table 5-2 also contains traffic volume information for ANAK as well as the location for which the traffic volume was obtained. Additionally, Table 5-2 presents the county-level daily VMT for the Anchorage Municipality from the 2011 NEI, version 2.

Table 5-2. Population, Motor Vehicle, and Traffic Information for the Alaska Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
ANAK	Anchorage	300,950	358,999	20,193	Debarr Rd between Airport Heights Dr and Bragaw St	5,301,813

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2013 data (AK DMV, 2014)

³AADT reflects 2012 data (AK DOT, 2012)

⁴County-level VMT reflects 2011 data (EPA, 2015a)

Observations from Table 5-2 include the following:

- The population for the Anchorage Municipality is in the middle-third compared to other counties with NMP sites. The county-level vehicle registration has a similar ranking compared to other counties with NMP sites.
- The traffic volume near ANAK is in the middle of the range compared to other NMP sites. The traffic estimate provided is for Debarr Road between Airport Heights Drive and Bragaw Street.
- The daily VMT for the Anchorage Municipality is 5.3 million miles and ranks in the bottom-third compared to other counties with NMP sites.

5.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Alaska on sample days, as well as over the course of the year.

5.2.1 Climate Summary

The city of Anchorage is surrounded by the waters of the Cook Inlet to the north, west, and south. The climate of Anchorage is considered a transition zone from maritime to continental (WRCC, 2014). The Chugach Mountains to the south and east prevent warm, moist air from moving northward from the Gulf of Alaska while the Alaska Range to the north and west acts as a barrier to very cold air moving southward. Although there are four distinct seasons in Anchorage, winters are long, extending from October through April, and snowfall is common. Due to its high latitude, daylight lasts about 19 hours in June and only 6 hours in December. Winds are generally light, although very strong winds off the surrounding mountains occur occasionally during the winter. The prevailing wind direction in Anchorage is from the north (Wood, 2004).

5.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Alaska monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station is located at Merrill Field Airport (WBAN 26409). Additional information about the Merrill Field Airport weather station, such as the distance between the site and the weather station, is provided in Table 5-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 5-3. Average Meteorological Conditions near the Alaska Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Anchorage, Alaska - ANAK									
Merrill Field Airport 26409 (61.22, -149.86)	1.3 miles 307° (NW)	Sample Days (64)	44.4 ± 4.7	38.4 ± 4.6	28.6 ± 4.4	34.5 ± 4.2	70.4 ± 3.4	1011.9 ± 2.5	3.1 ± 0.4
		2013	44.9 ± 1.9	38.8 ± 1.9	28.8 ± 1.8	34.9 ± 1.7	70.1 ± 1.5	1010.9 ± 1.1	3.2 ± 0.2

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 5-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 5-3 is the 95 percent confidence interval for each parameter. As shown in Table 5-3, average meteorological conditions on sample days are very similar to conditions experienced throughout 2013.

The average maximum temperature and average daily temperature calculated for ANAK for 2013 are the lowest among all NMP sites. This site also has the lowest average sea level pressure for 2013 among NMP sites.

5.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at Merrill Field Airport near ANAK were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

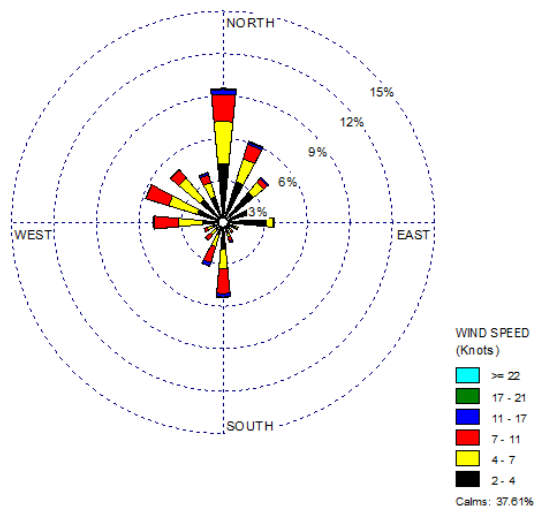
Figure 5-3 presents a map showing the distance between the weather station and ANAK, which may be useful for identifying topographical influences that can affect the meteorological patterns experienced at this location. Figure 5-3 also presents three different wind roses for the ANAK monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 5-3. Wind Roses for the Merrill Field Airport Weather Station near ANAK

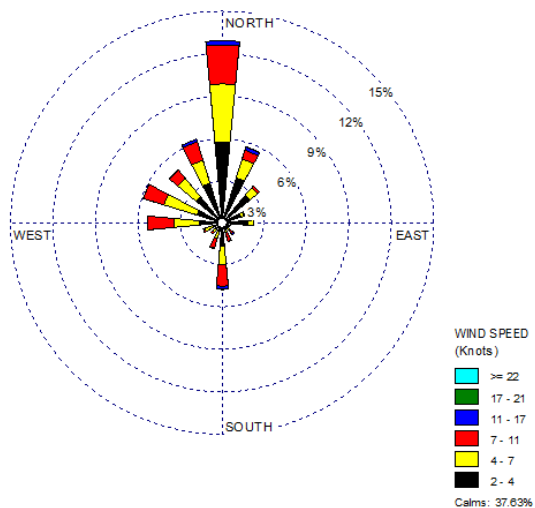
Location of ANAK and Weather Station



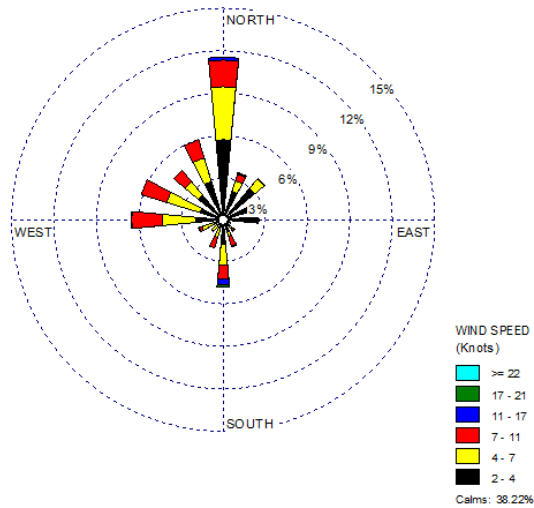
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 5-3 for ANAK include the following:

- The Merrill Field Airport weather station is located 1.3 miles northwest of ANAK. Most of the airport property as well as a hospital lie between the weather station and ANAK.
- The historical wind rose shows that calm winds (those less than or equal to 2 knots) were observed for nearly 40 percent of the hourly measurements over the last 10 years. For wind speeds greater than 2 knots, winds from the north were observed most frequently (10 percent). Winds from the north-northeast and west to northwest each account for another 5 percent to 6 percent of observations. With the exception of southerly winds, winds from the southeast and southwest quadrants were observed infrequently near ANAK. Wind speeds greater than 17 knots account for too few observations near ANAK to be visible on the historical wind rose.
- The wind patterns shown on the 2013 wind rose resemble the historical wind patterns, although northerly winds account for a higher percentage of observations in 2013 (nearly 13 percent).
- The sample day wind rose exhibits most of the same characteristics as the other wind roses, with winds calm winds accounting for nearly 40 percent of observations and north as the predominant wind direction. However, fewer north-northeasterly winds were observed on sample days.

5.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for ANAK in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 5-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 5-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. VOCs and PAHs were sampled for at ANAK.

Table 5-4. Risk-Based Screening Results for the Alaska Monitoring Site

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Anchorage, Alaska - ANAK						
Benzene	0.13	61	61	100.00	18.43	18.43
Carbon Tetrachloride	0.17	61	61	100.00	18.43	36.86
1,3-Butadiene	0.03	51	54	94.44	15.41	52.27
1,2-Dichloroethane	0.038	49	49	100.00	14.80	67.07
Naphthalene	0.029	41	62	66.13	12.39	79.46
Ethylbenzene	0.4	38	61	62.30	11.48	90.94
<i>p</i> -Dichlorobenzene	0.091	11	38	28.95	3.32	94.26
Hexachloro-1,3-butadiene	0.045	7	9	77.78	2.11	96.37
Xylenes	10	5	61	8.20	1.51	97.89
Benzo(a)pyrene	0.00057	4	40	10.00	1.21	99.09
Acenaphthylene	0.011	2	51	3.92	0.60	99.70
Acenaphthene	0.011	1	62	1.61	0.30	100.00
Total		331	609	54.35		

Observations from Table 5-4 include the following:

- Sixty-one valid VOC samples were collected at ANAK and concentrations of eight VOCs failed screens. Sixty-two valid PAH samples were collected at ANAK and concentrations of four PAHs failed. In total, 12 pollutants failed screens for ANAK. More than half (54 percent) of all VOC and PAH concentrations measured at ANAK were greater than their associated risk screening value, or failed screens (of those pollutants for which a risk screening value is available).
- Eight pollutants contributed to 95 percent of failed screens for ANAK and therefore were identified as pollutants of interest for ANAK. These eight pollutants include seven VOCs and one PAH (naphthalene).
- Benzene and carbon tetrachloride were detected in every VOC sample collected at ANAK and failed 100 percent of screens; 1,2-dichloroethane also failed 100 percent of its screens but was detected less frequently. Naphthalene was detected in every PAH sample collected at ANAK and failed 66 percent of screens, the highest of the four PAHs that failed screens.

5.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Alaska monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at ANAK are provided in Appendices J and M.

5.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Alaska site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for ANAK are presented in Table 5-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 5-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Alaska Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Anchorage, Alaska - ANAK						
Benzene	61/61	2.17 ± 0.75	1.01 ± 0.39	0.72 ± 0.26	2.36 ± 0.83	1.56 ± 0.34
1,3-Butadiene	54/61	0.19 ± 0.09	0.08 ± 0.04	0.06 ± 0.03	0.26 ± 0.10	0.15 ± 0.04
Carbon Tetrachloride	61/61	0.60 ± 0.04	0.63 ± 0.04	0.67 ± 0.04	0.56 ± 0.05	0.62 ± 0.02
<i>p</i> -Dichlorobenzene	38/61	0.06 ± 0.03	0.05 ± 0.03	0.02 ± 0.01	0.07 ± 0.02	0.05 ± 0.01
1,2-Dichloroethane	49/61	0.09 ± 0.02	0.09 ± 0.03	0.05 ± 0.02	0.09 ± 0.03	0.08 ± 0.01
Ethylbenzene	61/61	1.21 ± 0.46	0.53 ± 0.23	0.40 ± 0.15	1.42 ± 0.59	0.89 ± 0.22
Hexachloro-1,3-butadiene	9/61	0.01 ± 0.01	<0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
Naphthalene ^a	62/62	75.17 ± 32.95	39.22 ± 13.53	30.74 ± 9.15	87.38 ± 33.79	58.29 ± 13.23

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for ANAK from Table 5-5 include the following:

- Benzene has the highest annual average concentration among the VOC pollutants of interest ($1.56 \pm 0.34 \mu\text{g}/\text{m}^3$) and is the only pollutant of interest with an annual average greater than $1 \mu\text{g}/\text{m}^3$. This annual average is the second highest benzene concentration among NMP sites sampling this pollutant, as shown in Table 4-9.
- The first and fourth quarter average concentrations of benzene are significantly greater than the second and third quarter averages, indicating that benzene concentrations tend to be higher during the colder months at ANAK. Concentrations of benzene measured at ANAK range from $0.288 \mu\text{g}/\text{m}^3$ to $6.18 \mu\text{g}/\text{m}^3$; this maximum benzene concentration is the fifth highest benzene concentration measured across the program. Of the 29 concentrations less than $1 \mu\text{g}/\text{m}^3$, 23 were measured during the second or third quarter of 2013 and none were measured during February, November, or December. Conversely, of the 10 concentrations greater than $3 \mu\text{g}/\text{m}^3$ measured at ANAK, all but one were measured during the first or fourth quarters of 2013.
- Ethylbenzene, 1,3-butadiene, and *p*-dichlorobenzene also exhibit this seasonal tendency but the differences among the quarterly averages are less significant.
- Naphthalene is the only PAH identified as a pollutant of interest for ANAK. Concentrations measured at ANAK were variable, ranging from $7.25 \text{ ng}/\text{m}^3$ to $266 \text{ ng}/\text{m}^3$. Naphthalene concentrations appear highest during the first and fourth quarters, similar to several of the VOCs. All but one of the nine naphthalene

measurements greater than 100 ng/m³ were measured during the first and fourth quarters while all but one of the 12 measurements less than 20 ng/m³ were measured during the second and third quarters.

5.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 5-4 for ANAK. Figures 5-4 through 5-11 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 5-4. Program vs. Site-Specific Average Benzene Concentration

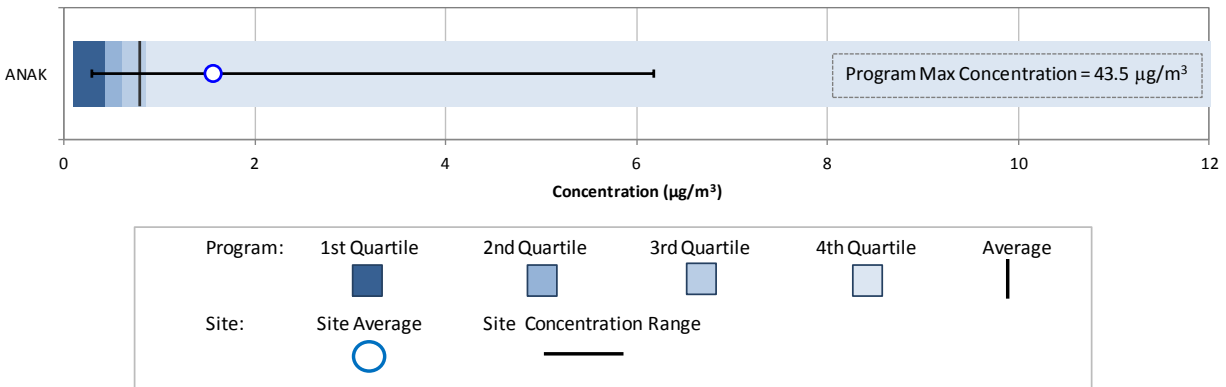


Figure 5-5. Program vs. Site-Specific Average 1,3-Butadiene Concentration

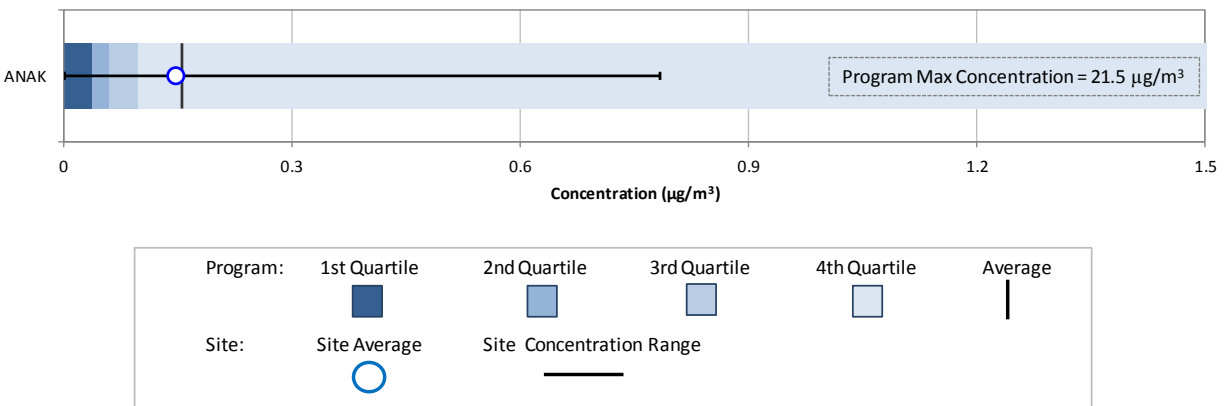


Figure 5-6. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

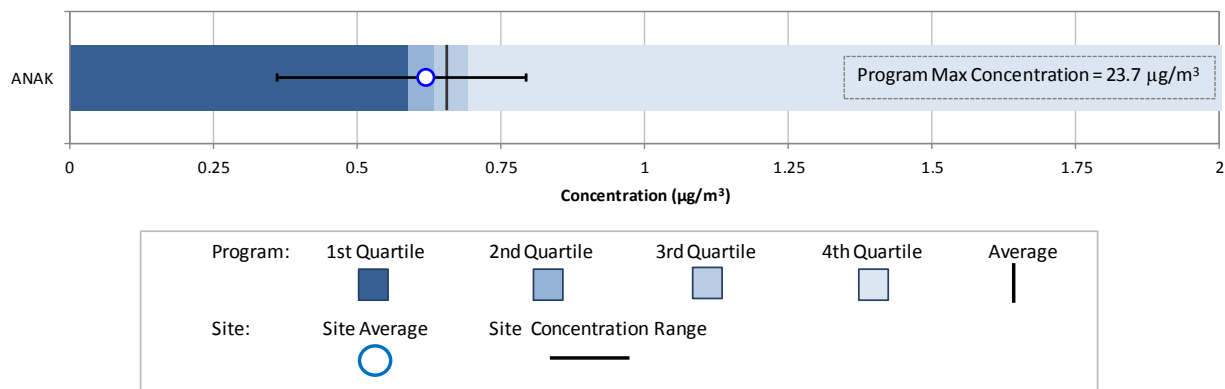


Figure 5-7. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentration

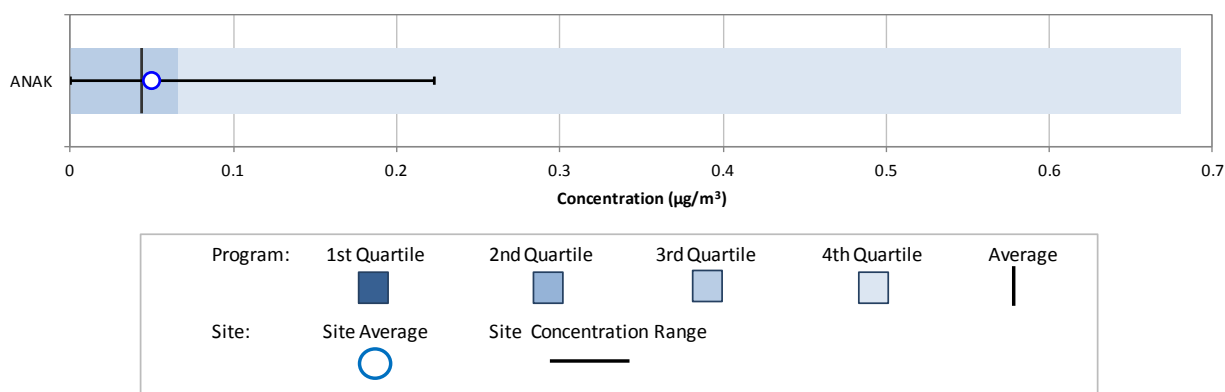


Figure 5-8. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

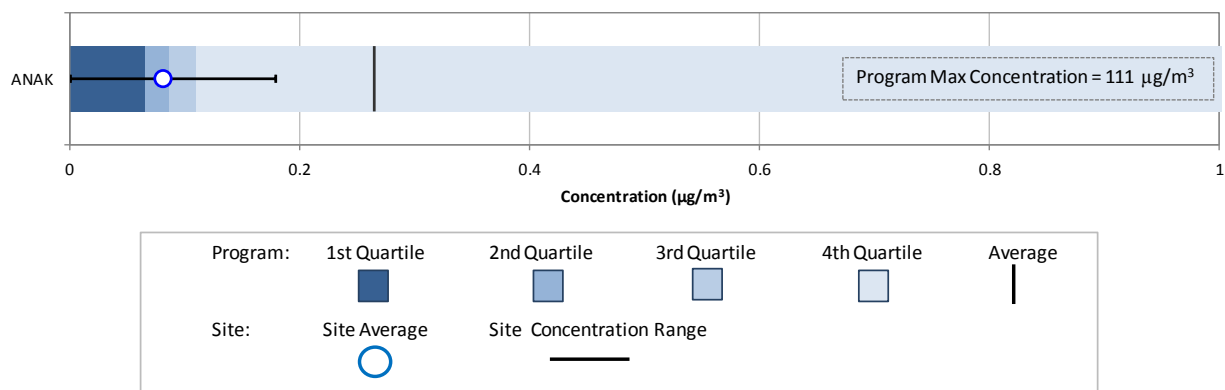


Figure 5-9. Program vs. Site-Specific Average Ethylbenzene Concentration

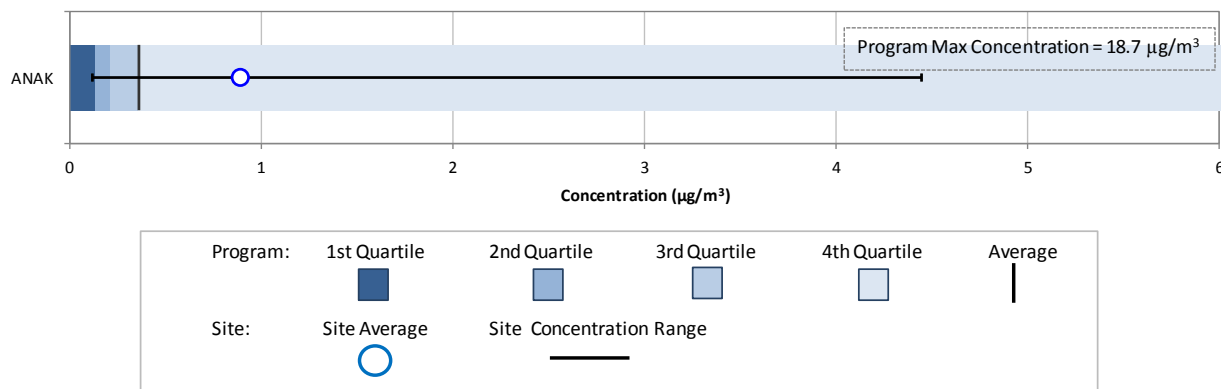


Figure 5-10. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentration

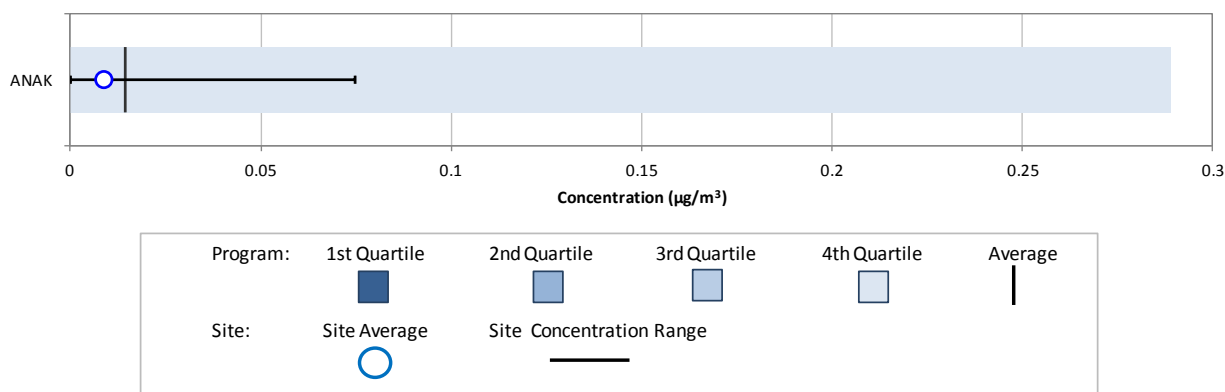
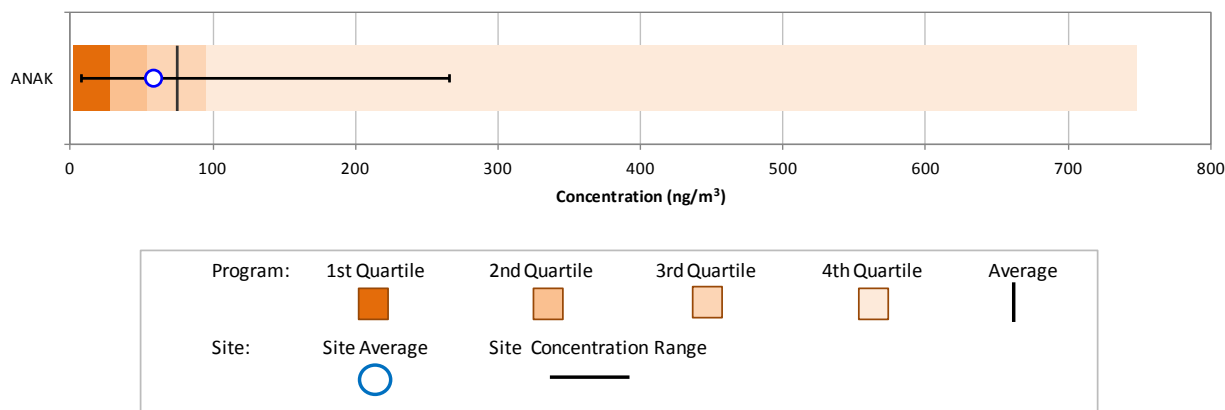


Figure 5-11. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figure 5-4 through 5-11 include the following:

- The program-level maximum benzene concentration ($43.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot in Figure 5-4 because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to $12 \mu\text{g}/\text{m}^3$. The

maximum benzene concentration measured at ANAK is roughly one-seventh the maximum concentration shown in Figure 5-4 and, as mentioned in the previous section, is the fifth highest benzene concentration measured across the program. The annual average concentration for ANAK is greater than the program-level first, second, and third quartiles and is twice the program-level average concentration. This site has the second highest annual average concentration of benzene, second only to PACO.

- Similar to benzene, the program-level maximum 1,3-butadiene concentration ($21.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot in Figure 5-5 because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to $1.5 \mu\text{g}/\text{m}^3$. Concentrations of 1,3-butadiene measured at ANAK range from zero (non-detect) to $0.783 \mu\text{g}/\text{m}^3$. The annual average concentration of 1,3-butadiene for ANAK ($0.15 \pm 0.04 \mu\text{g}/\text{m}^3$) is similar to the program-level average concentration.
- The scale of the box plot in Figure 5-6 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum carbon tetrachloride concentration ($23.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Concentrations of carbon tetrachloride measured at ANAK range from $0.359 \mu\text{g}/\text{m}^3$ to $0.794 \mu\text{g}/\text{m}^3$, with the annual average concentration for ANAK just less than both the program-level median and average concentrations.
- Figure 5-7 is the box plot for *p*-dichlorobenzene. Note that the program-level first and second quartiles are both zero and therefore not visible on the box plot. All of the *p*-dichlorobenzene measurements collected at ANAK are less than $0.25 \mu\text{g}/\text{m}^3$, including 23 non-detects. The annual average *p*-dichlorobenzene concentration for ANAK is just greater than the program-level average concentration.
- The scale of the box plot in Figure 5-8 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum 1,2-dichloroethane concentration ($111 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Note that all of the concentrations of 1,2-dichloroethane measured at ANAK are less than the program-level average concentration of $0.26 \mu\text{g}/\text{m}^3$. The annual average concentration for ANAK is similar to the program-level median concentration of $0.085 \mu\text{g}/\text{m}^3$.
- The scale of the box plot in Figure 5-9 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum ethylbenzene concentration ($18.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. ANAK is one of only three NMP sites to measure an ethylbenzene concentration greater than $3 \mu\text{g}/\text{m}^3$ (KMMS and BTUT are the others); in fact, two were measured at ANAK. The minimum ethylbenzene concentration measured at ANAK is similar to the program-level

first quartile. The annual average concentration for ANAK is more than twice the program-level average concentration of $0.36 \mu\text{g}/\text{m}^3$. As shown in Table 4-9, ANAK has the second highest annual average concentration of ethylbenzene among NMP sites sampling this pollutant, second only to KMMS.

- Figure 5-10 is the box plot for hexachloro-1,3-butadiene. Note that the program-level first, second, and third quartiles are zero and therefore not visible on the box plot. Sixty-one valid VOC samples were collected at ANAK and of these, hexachloro-1,3-butadiene was detected in only nine. Thus, many zeroes are substituted into the annual average concentration of this pollutant. Yet, the annual average for ANAK is less than the program-level average concentration of hexachloro-1,3-butadiene.
- The maximum naphthalene concentration measured at ANAK is considerably less than the maximum concentration measured across the program, as shown in Figure 5-11. The annual average naphthalene concentration for ANAK is less than the program-level average concentration but just greater than the program-level median concentration.

5.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. Although ANAK has sampled under the NMP previously, as shown in Table 2-1, sampling under the NMP did not begin again until January 2013 at ANAK; thus, a trends analysis was not conducted for this site.

5.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the Alaska monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

5.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Alaska site and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutant of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities.

Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 5-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 5-6. Risk Approximations for the Alaska Monitoring Site

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Anchorage, Alaska - ANAK						
Benzene	0.0000078	0.03	61/61	1.56 ± 0.34	12.15	0.05
1,3-Butadiene	0.00003	0.002	54/61	0.15 ± 0.04	4.39	0.07
Carbon Tetrachloride	0.000006	0.1	61/61	0.62 ± 0.02	3.71	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	38/61	0.05 ± 0.01	0.55	<0.01
1,2-Dichloroethane	0.000026	2.4	49/61	0.08 ± 0.01	2.09	<0.01
Ethylbenzene	0.0000025	1	61/61	0.89 ± 0.22	2.22	<0.01
Hexachloro-1,3-butadiene	0.000022	0.09	9/61	0.01 ± 0.01	0.19	<0.01
Naphthalene ^a	0.000034	0.003	62/62	58.29 ± 13.23	1.98	0.02

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for ANAK from Table 5-6 include the following:

- The pollutants with the highest annual average concentrations for ANAK are benzene, ethylbenzene, and carbon tetrachloride.
- The pollutants with the highest cancer risk approximations for ANAK are benzene, 1,3-butadiene, and carbon tetrachloride. The cancer risk approximation for benzene is 12.15 in-a-million, the only cancer risk approximation greater than 10 in-a-million calculated for ANAK. This is the second highest cancer risk approximation calculated for benzene across the program.
- The noncancer hazard approximations for ANAK's pollutants of interest are all considerably less than 1.0. Noncancer hazard approximations less than 1.0 indicate that no adverse noncancer health effects are expected from these individual pollutants.

5.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 5-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 5-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 5-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for ANAK, as presented in Table 5-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 5-7. Table 5-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 5.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 5-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Alaska Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Anchorage, Alaska (Anchorage Municipality) - ANAK					
Formaldehyde	253.72	Formaldehyde	3.30E-03	Benzene	12.15
Benzene	231.07	Benzene	1.80E-03	1,3-Butadiene	4.39
Acetaldehyde	111.90	1,3-Butadiene	1.33E-03	Carbon Tetrachloride	3.71
Ethylbenzene	106.03	POM, Group 2b	6.35E-04	Ethylbenzene	2.22
1,3-Butadiene	44.36	Naphthalene	6.04E-04	1,2-Dichloroethane	2.09
Naphthalene	17.76	Ethylbenzene	2.65E-04	Naphthalene	1.98
POM, Group 2b	7.21	Arsenic, PM	2.47E-04	<i>p</i> -Dichlorobenzene	0.55
Tetrachloroethylene	2.36	Acetaldehyde	2.46E-04	Hexachloro-1,3-butadiene	0.19
POM, Group 2d	2.05	POM, Group 2d	1.80E-04		
Trichloroethylene	0.74	POM, Group 5a	1.42E-04		

Table 5-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Alaska Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Anchorage, Alaska (Anchorage Municipality) - ANAK					
Toluene	1,267.81	Acrolein	1,587,012.31	1,3-Butadiene	0.07
Xylenes	407.80	Formaldehyde	25,890.03	Benzene	0.05
Formaldehyde	253.72	1,3-Butadiene	22,179.52	Naphthalene	0.02
Hexane	245.02	Acetaldehyde	12,433.63	Carbon Tetrachloride	0.01
Benzene	231.07	Benzene	7,702.29	Ethylbenzene	<0.01
Methanol	185.91	Lead, PM	6,641.46	Hexachloro-1,3-butadiene	<0.01
Acetaldehyde	111.90	Naphthalene	5,919.53	<i>p</i> -Dichlorobenzene	<0.01
Ethylbenzene	106.03	Xylenes	4,078.00	1,2-Dichloroethane	<0.01
Ethylene glycol	61.50	Arsenic, PM	3,835.37		
1,3-Butadiene	44.36	Cadmium, PM	3,056.13		

Observations from Table 5-7 include the following:

- Formaldehyde, benzene, and acetaldehyde are the highest emitted pollutants with cancer UREs within the Anchorage Municipality.
- Formaldehyde and benzene are also the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for the Anchorage Municipality, followed by 1,3-butadiene.
- Eight of the highest emitted pollutants within the Anchorage Municipality also have the highest toxicity-weighted emissions.
- Benzene is the pollutant with the highest cancer risk approximation for ANAK and ranks second for quantity emitted and its toxicity-weighted emissions. 1,3-Butadiene, ethylbenzene, and naphthalene also appear on all three lists in Table 5-7. The remaining four pollutants of interest for ANAK do not appear among the highest emitted pollutants or those with the highest toxicity-weighted emissions.
- Although formaldehyde tops both emissions-based lists in Table 5-7, carbonyl compounds were not measured at ANAK under the NMP.
- Several POM Groups rank among Anchorage's highest emitted pollutants and the pollutants with the highest toxicity-weighted emissions. POM, Group 2b includes acenaphthene and acenaphthylene, both of which failed screens for ANAK but were not identified as pollutants of interest. POM Group 5a, which ranks tenth for its toxicity-weighted emissions, includes benzo(a)pyrene, which failed 10 percent of its screens but was not identified as a pollutant of interest for ANAK. POM, Group 2d, which appears on both emissions-based lists, includes anthracene, phenanthrene, and pyrene, none of which failed screens for ANAK.

Observations from Table 5-8 include the following:

- Toluene, xylenes, and formaldehyde are the highest emitted pollutants with noncancer RfCs within the Anchorage Municipality. The emissions of toluene are considerably greater than those of the other pollutants listed.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and 1,3-butadiene. Although acrolein was sampled for at ANAK, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. The emissions of acrolein for Anchorage rank 11th.
- Five of the highest emitted pollutants within the Anchorage Municipality also have the highest toxicity-weighted emissions. Although toluene ranks highest for total emissions, it ranks 16th for its toxicity-weighted emissions, which speaks to the relative toxicity of toluene.

- Benzene and 1,3-butadiene appear on all three lists in Table 5-8, although none of ANAK's pollutant of interest have noncancer hazard approximations greater than 1.0.

5.6 Summary of the 2013 Monitoring Data for ANAK

Results from several of the data treatments described in this section include the following:

- ❖ *VOCs and PAHs were sampled for at ANAK throughout 2013.*
- ❖ *Twelve pollutants failed screens for ANAK, eight VOCs and four PAHs.*
- ❖ *Of the site-specific pollutants of interest for ANAK, benzene had the highest annual average concentration. ANAK has the second highest annual average concentrations of benzene and ethylbenzene among NMP sites sampling these pollutants.*
- ❖ *Concentrations of several VOCs, including benzene and ethylbenzene, tended to be higher during the colder months of the year.*
- ❖ *Benzene has the highest cancer risk approximation of the pollutants of interest for ANAK. None of the pollutants of interest have noncancer hazard approximations greater than an HQ of 1.0.*

6.0 Sites in Arizona

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Arizona, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

6.1 Site Characterization

This section characterizes the Arizona monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The Arizona monitoring sites are located in Phoenix, Arizona. Figures 6-1 and 6-2 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites and their immediate surroundings. Figure 6-3 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 6-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile boundaries are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 6-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

6-2

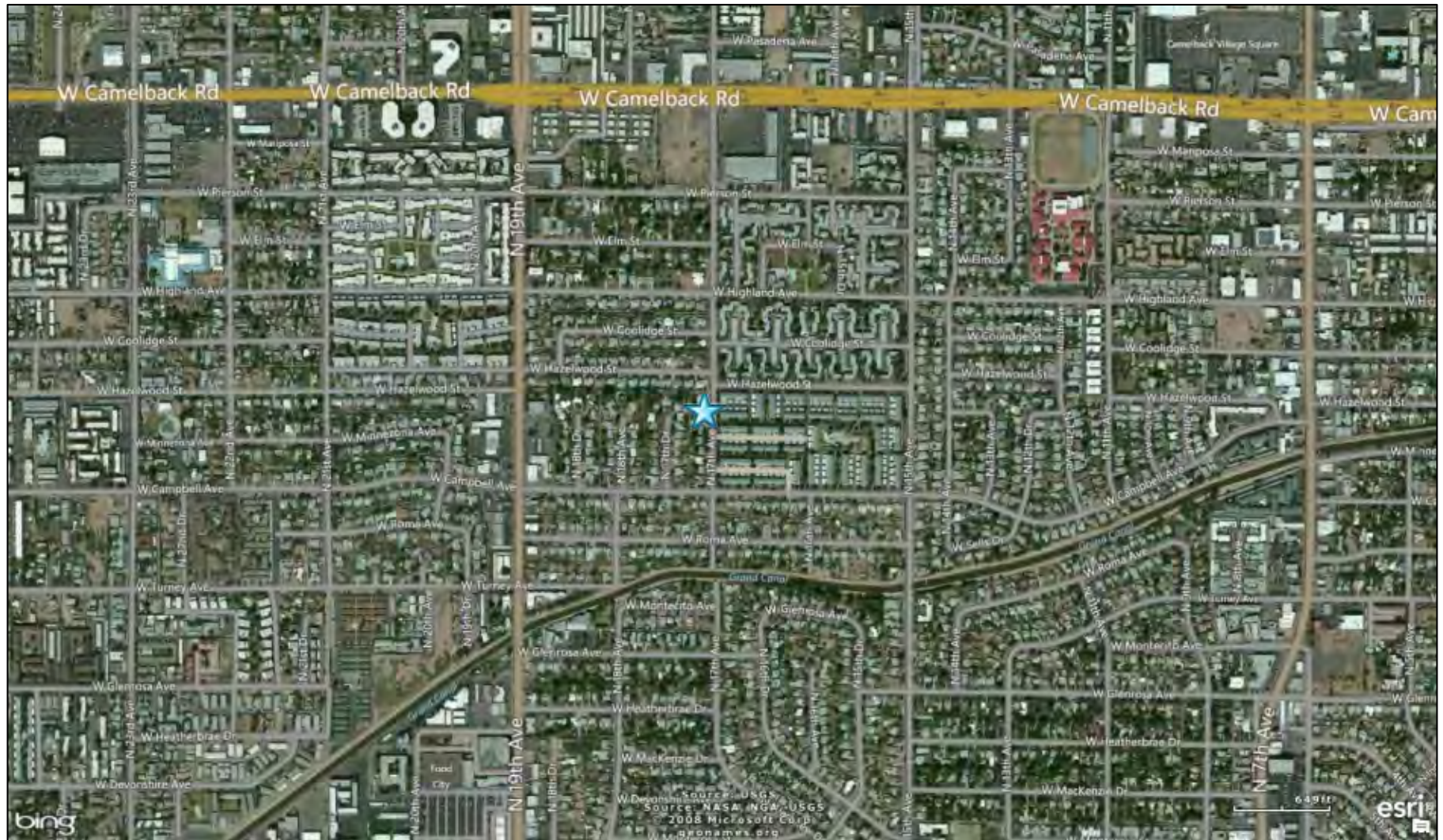


Figure 6-2. South Phoenix, Arizona (SPAZ) Monitoring Site

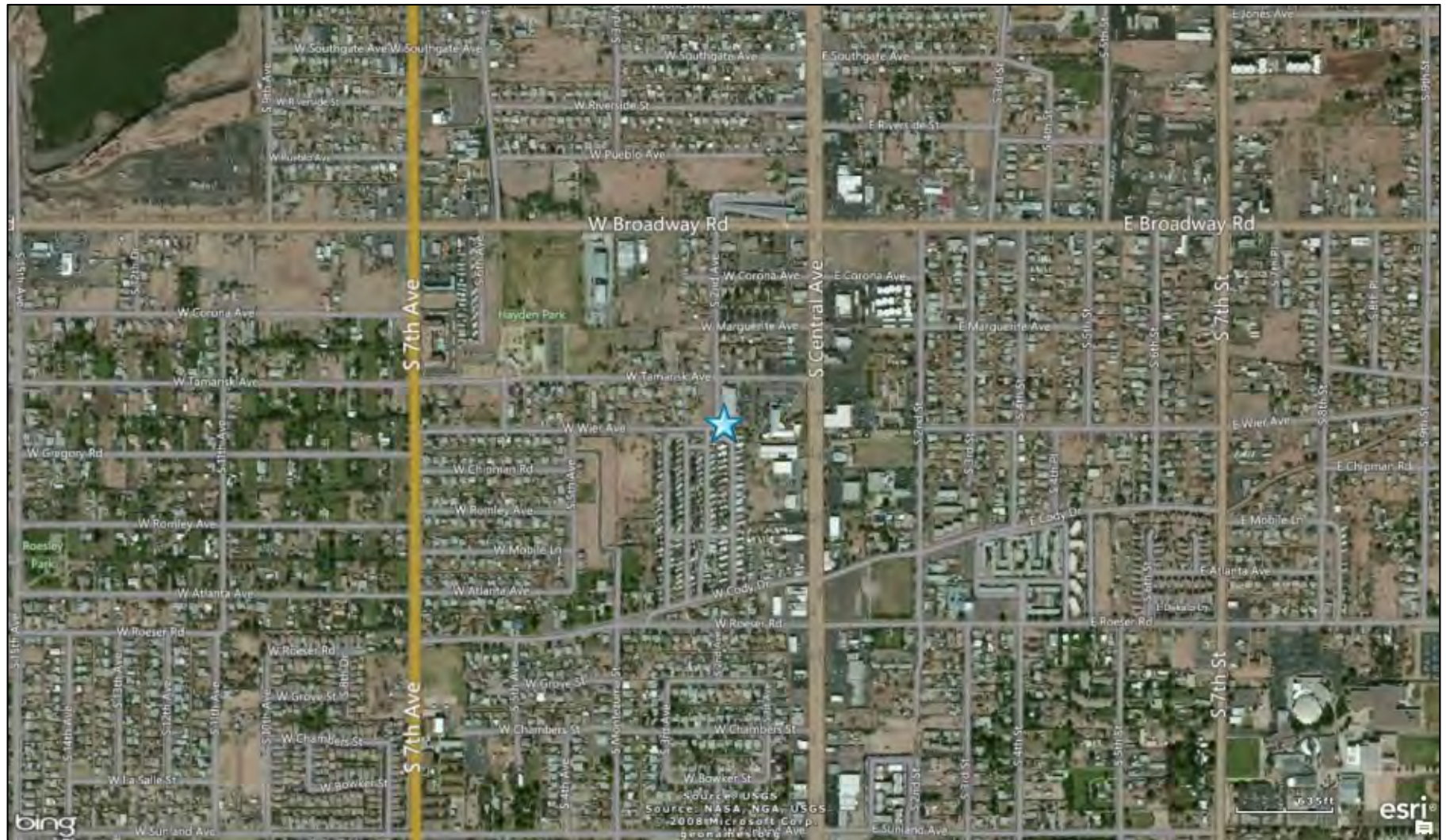


Figure 6-3. NEI Point Sources Located Within 10 Miles of PXSS and SPAZ

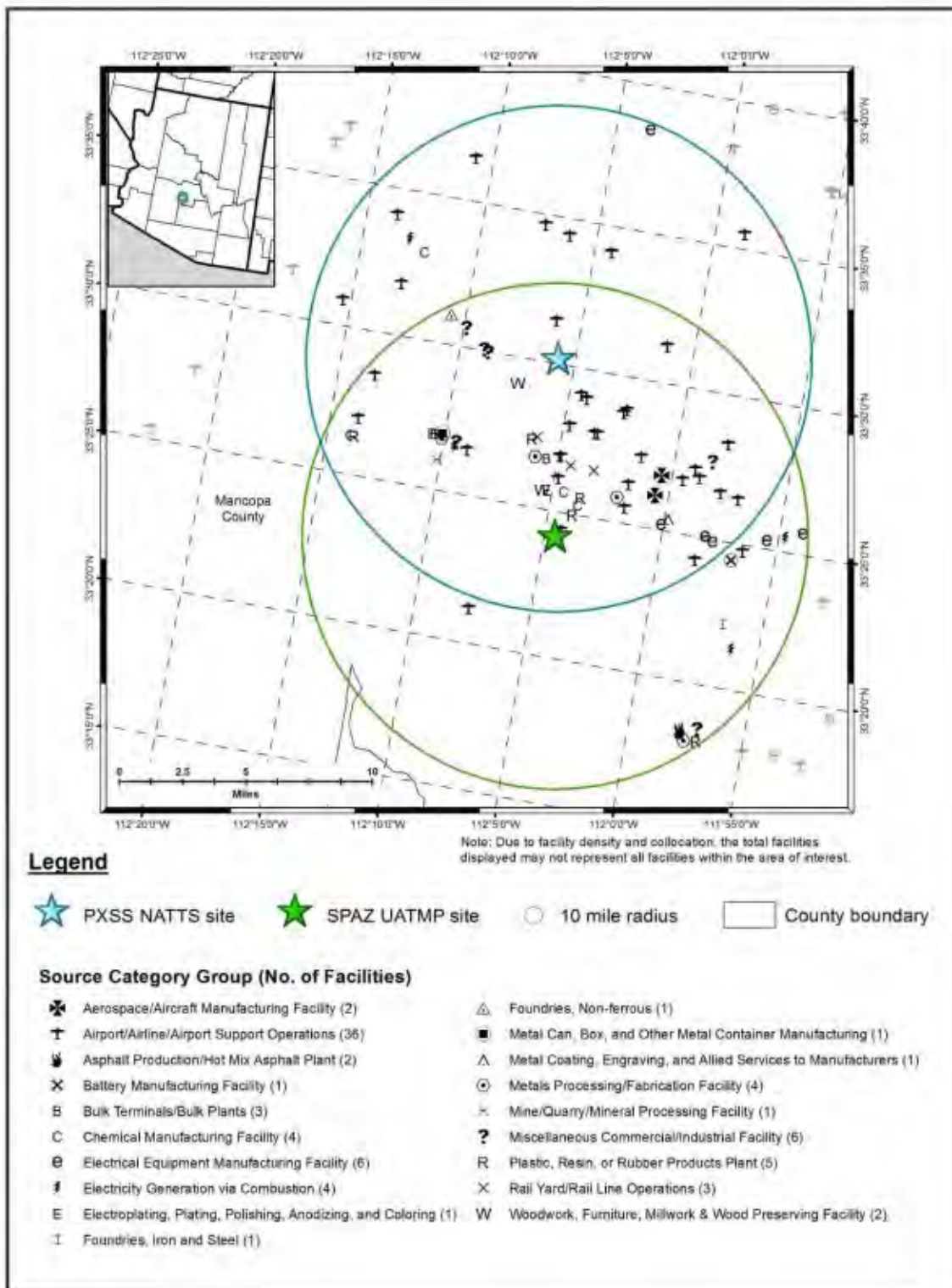


Table 6-1. Geographical Information for the Arizona Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>PXSS</i>	04-013-9997	Phoenix	Maricopa	Phoenix-Mesa-Scottsdale, AZ	33.503833, -112.095767	Residential	Urban/City Center	Haze, CO, SO ₂ , NO, NO ₂ , NO _x , NO _y , O ₃ , SO ₂ , Meteorological parameters, PM ₁₀ , PM Coarse, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
SPAZ	04-013-4003	Phoenix	Maricopa	Phoenix-Mesa-Scottsdale, AZ	33.40316, -112.07533	Residential	Urban/City Center	CO, O ₃ , Meteorological parameters, PM ₁₀ , PM Coarse, PM _{2.5} , PM _{2.5} Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

PXSS is located in central Phoenix. Figure 6-1 shows that PXSS is located in a highly residential area on North 17th Avenue. The Grand Canal is shown along the bottom of Figure 6-1. The monitoring site is approximately three-quarters of a mile east of I-17 and 2 miles north of I-10. Figure 6-2 shows that SPAZ is located in South Phoenix near the intersection of West Tamarisk Avenue and South Central Avenue. SPAZ is surrounded by residential properties to the west and south and commercial properties to the east. SPAZ is located approximately 1 mile south of I-17/I-10.

PXSS is located approximately 7 miles north of SPAZ. The majority of emissions sources are located between the sites, to the south of PXSS and north of SPAZ, as shown in Figure 6-3. The source category with the greatest number of emissions sources near these monitoring sites is the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. The emissions source nearest PXSS is a hospital heliport while the source nearest SPAZ is a heliport at a police station.

Table 6-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Arizona monitoring sites. Table 6-2 includes both county-level population and vehicle registration information. Table 6-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 6-2 presents the county-level daily VMT for Maricopa County.

Table 6-2. Population, Motor Vehicle, and Traffic Information for the Arizona Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
PXSS	Maricopa	4,009,412	3,761,859	29,515	W Camelback Rd on either side of N 17th Ave	90,393,000
SPAZ				25,952	Central Ave, south of Tamarisk	

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2012 data (AZ DOT, 2011)

³AADT reflects 2010 data for PXSS and 2011 data for SPAZ (AZ DOT, 2014)

⁴County-level VMT reflects 2012 data (AZ DOT, 2013)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 6-2 include the following:

- Maricopa County has the fourth highest county-level population and second highest county-level vehicle registration compared to other counties with NMP sites.
- Although PXSS experiences a higher traffic volume compared to SPAZ, the traffic volumes near these sites rank in the middle of the range compared to traffic volumes near other NMP sites.
- The daily VMT for Maricopa County is more than 90 million miles, which is the second highest compared to other counties with NMP sites.

6.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Arizona on sample days, as well as over the course of the year.

6.2.1 Climate Summary

Phoenix is located in the Salt River Valley, which is part of the Sonora Desert. The area experiences mild winters and extremely hot and dry summers. Differences between the daytime maximum temperature and overnight minimum temperature can be as high as 50°F. A summer “monsoon” period brings precipitation to the area for part of the summer, while storm systems originating over the Pacific Ocean bring rain in the winter and early spring. However, normal monthly rainfall totals are generally less than 1 inch. Winds are generally light and out of the east for much of the year (Wood, 2004; WRCC, 2014).

6.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Arizona monitoring sites (NCDC, 2013), as described in Section 3.4.2. The closest weather station to both PXSS and SPAZ is located at Phoenix Sky Harbor International Airport (WBAN 23183). Additional information about the Phoenix Sky Harbor weather station, such as the distance between the sites and the weather station, is provided in Table 6-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 6-3. Average Meteorological Conditions near the Arizona Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Phoenix, Arizona - PXSS									
Phoenix Sky Harbor Intl. Airport 23183 (33.43, -112.00)	7.5 miles	Sample Days (66)	85.7 ± 4.0	75.2 ± 3.9	34.7 ± 3.6	54.8 ± 2.5	28.4 ± 3.7	1012.0 ± 1.4	5.3 ± 0.5
	135° (SE)	2013	86.6 ± 1.7	76.1 ± 1.7	36.2 ± 1.5	55.6 ± 1.1	29.1 ± 1.6	1011.5 ± 0.6	5.4 ± 0.2
South Phoenix, Arizona - SPAZ									
Phoenix Sky Harbor Intl. Airport 23183 (33.43, -112.00)	4.5 miles	Sample Days (35)	85.5 ± 6.1	75.2 ± 5.8	35.1 ± 4.5	54.6 ± 3.5	28.9 ± 5.2	1011.4 ± 2.1	5.4 ± 0.6
	68° (ENE)	2013	86.6 ± 1.7	76.1 ± 1.7	36.2 ± 1.5	55.6 ± 1.1	29.1 ± 1.6	1011.5 ± 0.6	5.4 ± 0.2

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 6-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 6-3 is the 95 percent confidence interval for each parameter. As shown in Table 6-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year. The greatest difference between the sample day and full-year averages was calculated for average dew point temperature for PXSS, although the difference is not statistically significant.

The number of sample days for each site is provided in Table 6-3. Samples were collected on a 1-in-6 day schedule at PXSS while samples were collected on a 1-in-12 day schedule at SPAZ, yielding roughly half the number of collection events; thus, the number of observations included in each sample day calculation for SPAZ is less. The difference in the number of sample days is reflected in the larger confidence intervals for SPAZ (the fewer observations, generally the larger the confidence intervals).

These sites experienced the warmest temperatures among NMP sites in 2013, based on both average temperatures and average maximum temperatures for 2013. These sites also experienced the lowest relative humidity levels among all NMP sites in 2013, based on average relative humidity for 2013.

6.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at Phoenix Sky Harbor International Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 6-4 presents a map showing the distance between the weather station and PXSS, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 6-4 also presents three different wind roses for the PXSS monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended

period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind observations for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 6-5 presents the distance map and three wind roses for SPAZ.

Observations from Figures 6-4 and 6-5 for the Arizona monitoring sites include the following:

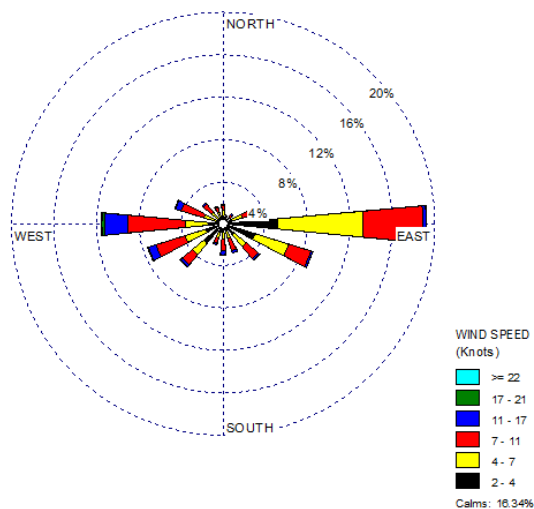
- The weather station at Phoenix Sky Harbor International Airport is the closest weather station to both PXSS and SPAZ. The Phoenix Sky Harbor weather station is located 7.5 miles southeast of PXSS and 4.5 miles east-northeast of SPAZ.
- Because the Phoenix Sky Harbor weather station is the closest weather station to both sites, the historical and 2013 wind roses for PXSS are the same as those for SPAZ.
- The historical wind rose shows that easterly winds were the most commonly observed winds near PXSS and SPAZ (accounting for approximately 19 percent of wind observations), followed by westerly (12 percent) and east-southeasterly (9 percent) winds. Winds from the northwest to north to northeast were infrequently observed, as were winds from the south-southeast to south-southwest. Calm winds (those less than or equal to 2 knots) account for 16 percent of the hourly wind measurements from 2003 to 2012.
- The 2013 wind patterns are similar to the historical wind patterns. Further, the sample day wind patterns for each site resemble both the historical and 2013 wind patterns, indicating that wind conditions on sample days were representative of those experienced over the entire year and historically.

Figure 6-4. Wind Roses for the Phoenix Sky Harbor International Airport Weather Station near PXSS

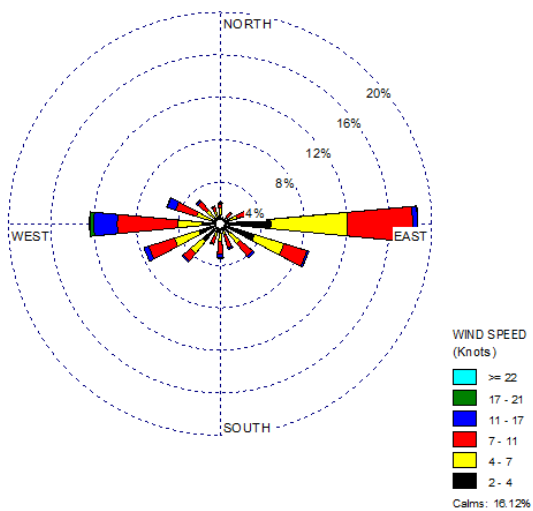
Location of PXSS and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

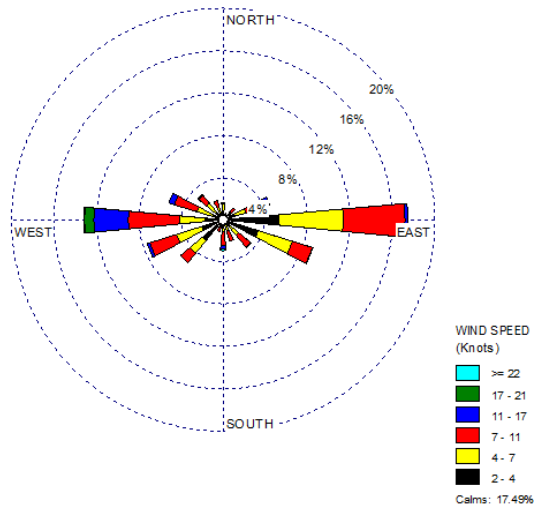
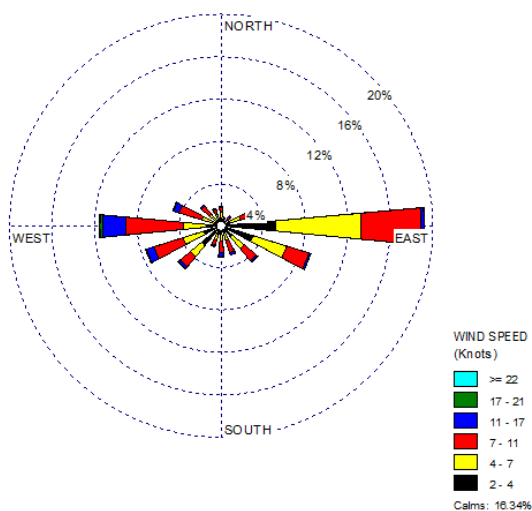


Figure 6-5. Wind Roses for the Phoenix Sky Harbor International Airport Weather Station near SPAZ

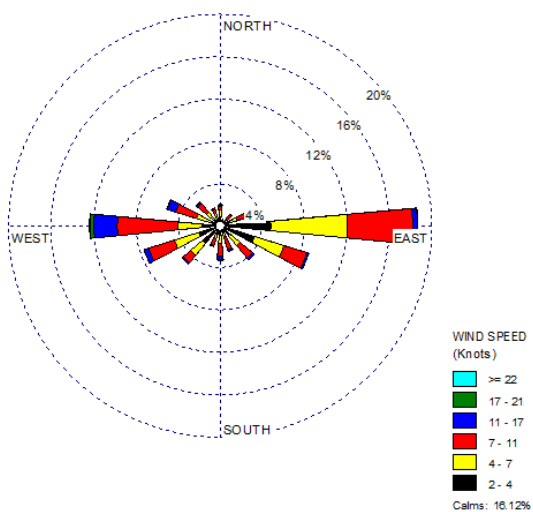
Location of SPAZ and Weather Station



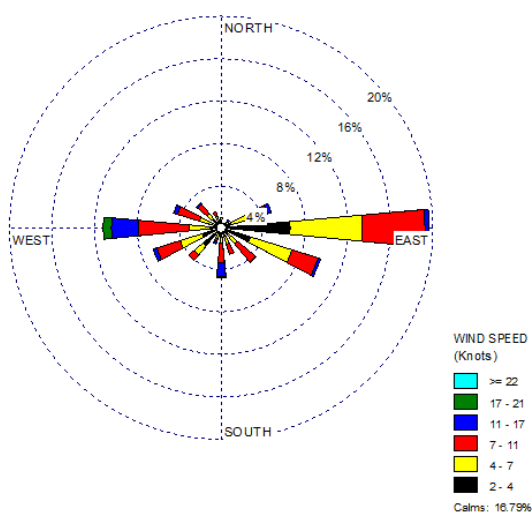
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



6.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Arizona monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 6-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 6-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. VOCs, carbonyl compounds, PAHs, metals (PM₁₀), and hexavalent chromium were sampled for at PXSS; VOCs were the only pollutants sampled for at SPAZ. Note that hexavalent chromium sampling was discontinued at PXSS at the end of June 2013.

Table 6-4. Risk-Based Screening Results for the Arizona Monitoring Sites

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Phoenix, Arizona - PXSS						
Benzene	0.13	61	61	100.00	11.01	11.01
Carbon Tetrachloride	0.17	61	61	100.00	11.01	22.02
Formaldehyde	0.077	60	60	100.00	10.83	32.85
Acetaldehyde	0.45	59	60	98.33	10.65	43.50
1,3-Butadiene	0.03	58	60	96.67	10.47	53.97
Arsenic (PM ₁₀)	0.00023	52	61	85.25	9.39	63.36
<i>p</i> -Dichlorobenzene	0.091	51	58	87.93	9.21	72.56
Naphthalene	0.029	50	58	86.21	9.03	81.59
1,2-Dichloroethane	0.038	38	38	100.00	6.86	88.45
Ethylbenzene	0.4	37	61	60.66	6.68	95.13
Hexachloro-1,3-butadiene	0.045	8	8	100.00	1.44	96.57
Nickel (PM ₁₀)	0.0021	8	61	13.11	1.44	98.01
Manganese	0.03	4	61	6.56	0.72	98.74
Benzo(a)pyrene	0.00057	3	36	8.33	0.54	99.28
Cadmium (PM ₁₀)	0.00056	1	61	1.64	0.18	99.46
<i>cis</i> -1,3-Dichloropropene	0.25	1	4	25.00	0.18	99.64
<i>trans</i> -1,3-Dichloropropene	0.25	1	2	50.00	0.18	99.82
Hexavalent Chromium	0.000083	1	27	3.70	0.18	100.00
Total		554	838	66.11		

Table 6-4. Risk-Based Screening Results for the Arizona Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
South Phoenix, Arizona - SPAZ						
Benzene	0.13	31	31	100.00	19.50	19.50
1,3-Butadiene	0.03	31	31	100.00	19.50	38.99
Carbon Tetrachloride	0.17	31	31	100.00	19.50	58.49
<i>p</i> -Dichlorobenzene	0.091	27	30	90.00	16.98	75.47
Ethylbenzene	0.4	20	31	64.52	12.58	88.05
1,2-Dichloroethane	0.038	19	19	100.00	11.95	100.00
Total		159	173	91.91		

Observations from Table 6-4 include the following:

- The number of pollutants failing screens varied significantly between the two monitoring sites; this is expected given the difference in pollutants measured at each site.
- Eighteen pollutants failed at least one screen for PXSS; 66 percent of concentrations for these 18 pollutants were greater than their associated risk screening value (or failed screens).
- Ten pollutants contributed to 95 percent of failed screens for PXSS and therefore were identified as pollutants of interest for PXSS. These 10 include two carbonyl compounds, six VOCs, one PM₁₀ metal, and one PAH.
- PXSS failed the second highest number of screens (554) among all NMP sites, behind only S4MO with 574 failed screens (refer to Table 4-8 of Section 4.2). However, the failure rate for PXSS, when incorporating all pollutants with screening values, is relatively low, at 23 percent. This is due primarily to the relatively high number of pollutants sampled for at this site, as discussed in Section 4.2.
- Six pollutants failed screens for SPAZ; approximately 92 percent of concentrations for these six pollutants were greater than their associated risk screening value (or failed screens). This percentage is greater than the percentage for PXSS. However, nearly all of the measured detections for the pollutants listed for SPAZ failed screens; for PXSS, the percentage of screens failed for each individual pollutant is more varied.
- All six pollutants contributed to 95 percent of failed screens for SPAZ and therefore were identified as pollutants of interest for this site.
- Of the VOCs measured at these sites, benzene and carbon tetrachloride were detected in all valid samples and failed 100 percent of screens for each site. This was also true for 1,3-butadiene for SPAZ. Other VOCs, such as 1,2-dibromoethane (for both sites)

and hexachloro-1,3-butadiene (for PXSS), also failed 100 percent of screens, but were detected less frequently.

- Formaldehyde also failed 100 percent of screens for PXSS (and was detected in all of the valid samples collected at this site).

6.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Arizona monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual average concentrations are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at PXSS and SPAZ are provided in Appendices J, L, M, N, and O.

6.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Arizona monitoring site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Arizona monitoring sites are presented in Table 6-5, where applicable. Note that concentrations

of the PAHs and metals for PXSS are presented in ng/m³ for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 6-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Arizona Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
Phoenix, Arizona - PXSS						
Acetaldehyde	60/60	2.71 ± 0.74	2.51 ± 0.42	2.24 ± 0.48	3.57 ± 0.48	2.78 ± 0.29
Benzene	61/61	1.42 ± 0.38	0.56 ± 0.13	0.55 ± 0.14	1.66 ± 0.30	1.06 ± 0.18
1,3-Butadiene	60/61	0.28 ± 0.10	0.08 ± 0.03	0.07 ± 0.02	0.40 ± 0.09	0.21 ± 0.05
Carbon Tetrachloride	61/61	0.65 ± 0.04	0.61 ± 0.04	0.63 ± 0.02	0.58 ± 0.02	0.62 ± 0.02
<i>p</i> -Dichlorobenzene	58/61	0.22 ± 0.07	0.15 ± 0.04	0.11 ± 0.04	0.33 ± 0.06	0.20 ± 0.03
1,2-Dichloroethane	38/61	0.09 ± 0.03	0.09 ± 0.02	0.03 ± 0.02	0.05 ± 0.03	0.07 ± 0.01
Ethylbenzene	61/61	0.78 ± 0.25	0.39 ± 0.09	0.41 ± 0.13	1.05 ± 0.19	0.67 ± 0.11
Formaldehyde	60/60	3.59 ± 0.61	3.87 ± 0.37	3.90 ± 0.28	4.20 ± 0.48	3.89 ± 0.22
Arsenic (PM ₁₀) ^a	61/61	0.57 ± 0.18	0.31 ± 0.10	0.51 ± 0.18	0.54 ± 0.15	0.49 ± 0.08
Naphthalene ^a	58/58	115.56 ± 38.99	51.89 ± 14.25	41.75 ± 13.28	157.35 ± 37.72	93.36 ± 18.63
South Phoenix, Arizona - SPAZ						
Benzene	31/31	1.23 ± 0.53	0.68 ± 0.12	0.69 ± 0.19	1.65 ± 0.33	1.07 ± 0.21
1,3-Butadiene	31/31	0.24 ± 0.16	0.11 ± 0.02	0.12 ± 0.08	0.40 ± 0.13	0.22 ± 0.07
Carbon Tetrachloride	31/31	0.58 ± 0.06	0.65 ± 0.05	0.63 ± 0.04	0.57 ± 0.03	0.61 ± 0.02
<i>p</i> -Dichlorobenzene	30/31	0.17 ± 0.10	0.16 ± 0.03	0.18 ± 0.05	0.35 ± 0.09	0.22 ± 0.04
1,2-Dichloroethane	19/31	0.10 ± 0.02	0.08 ± 0.05	0.03 ± 0.03	0.04 ± 0.04	0.06 ± 0.02
Ethylbenzene	31/31	0.70 ± 0.37	0.50 ± 0.08	0.45 ± 0.17	1.05 ± 0.37	0.68 ± 0.15

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m³ for ease of viewing.

Observations for PXSS from Table 6-5 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde ($3.89 \pm 0.22 \mu\text{g}/\text{m}^3$), acetaldehyde ($2.78 \pm 0.29 \mu\text{g}/\text{m}^3$), and benzene ($1.06 \pm 0.18 \mu\text{g}/\text{m}^3$). These are the only pollutants of interest with annual average concentrations greater than $1 \mu\text{g}/\text{m}^3$ for this site.
- The first and fourth quarter average concentrations for benzene and 1,3-butadiene are significantly greater than the second and third quarter average concentrations, supporting the seasonal tendency discussed in Section 4.4.2, with higher quarterly averages for the quarters that include colder months of the year. The quarterly averages for *p*-dichlorobenzene and ethylbenzene exhibit a similar tendency but the differences among the quarterly averages are not statistically significant.
- The fourth quarter average concentrations of many of PXSS's pollutants of interest (including acetaldehyde, formaldehyde, benzene, and naphthalene) are higher than the other quarterly averages, yet the confidence intervals are highest for many of the first quarter averages. A review of the data shows that the highest concentrations of benzene, acetaldehyde, and formaldehyde were measured on January 22, 2013, while many of the other higher concentrations were measured during the fourth quarter. Several of PXSS's pollutant of interest were highest on December 18, 2013, including 1,3-butadiene, ethylbenzene, and naphthalene (and the second highest concentrations of benzene and acetaldehyde were also measured on this date).
- 1,2-Dichloroethane concentrations appear highest during the first half of 2013. This pollutant was detected in roughly 60 percent of the VOC samples collected. This pollutant was detected in 25 of the 30 VOC samples collected from January through June but only 13 of the 31 samples collected during the second half of the year.
- Arsenic is the only metal pollutant of interest for PXSS. The second quarter average concentration of arsenic ($0.31 \pm 0.10 \text{ ng}/\text{m}^3$) is considerably less than the other quarterly averages (all greater than $0.50 \text{ ng}/\text{m}^3$). The second quarter is the only quarter in which an arsenic concentration greater than $1 \text{ ng}/\text{m}^3$ was not measured (the maximum for the second quarter is $0.77 \text{ ng}/\text{m}^3$).
- Based on the quarterly averages shown in Table 6-5, measurements of naphthalene measured at PXSS are highly variable. Concentrations span an order of magnitude, ranging from $18.9 \text{ ng}/\text{m}^3$ to $287 \text{ ng}/\text{m}^3$. The first and fourth quarterly average concentrations are significantly greater than the other quarterly average, similar to several of the VOCs. All but two of the 22 concentrations of naphthalene greater than $100 \text{ ng}/\text{m}^3$ were measured in the first and fourth quarters of 2013.

Observations for SPAZ from Table 6-5 include the following:

- The pollutant of interest with the highest annual average concentration for SPAZ is benzene ($1.07 \pm 0.21 \mu\text{g}/\text{m}^3$), which is the only pollutant of interest with an annual average concentration greater than $1 \mu\text{g}/\text{m}^3$. The annual average concentration of benzene for SPAZ is similar to the annual average benzene concentration of PXSS.

- Similar to PXSS, benzene and 1,3-butadiene concentrations were highest during the first and fourth quarters of 2013 at SPAZ. This is also true for ethylbenzene. However, the confidence intervals calculated for these averages indicate that the concentrations included in the quarterly averages are variable, particularly for the first quarter.
- The fourth quarter average concentration of *p*-dichlorobenzene is roughly twice the other quarterly averages for this pollutant. A review of the data shows that the only two concentrations greater than 0.4 µg/m³ were measured on October 19, 2013 (0.49 µg/m³) and November 12, 2013 (0.47 µg/m³). Further, seven of the nine *p*-dichlorobenzene concentrations greater than 0.3 µg/m³ were measured at SPAZ during the fourth quarter.
- Similar to PXSS, most of the measured detections of 1,2-dichloroethane were measured at SPAZ during the first half of 2013. During the first half of the year, 1,2-dichloroethane was detected in 13 of 15 valid samples; during the second half of the year, this pollutant was detected in only six of the 16 valid samples collected.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for PXSS and SPAZ from those tables include the following:

- PXSS and SPAZ appear in Tables 4-9 through 4-12 a total of 12 times.
- SPAZ and PXSS have the highest annual average concentrations of *p*-dichlorobenzene among all NMP sites sampling VOCs, similar to 2011 and 2012. These annual average concentrations of *p*-dichlorobenzene are roughly twice the next highest concentration shown in Table 4-9. Of the 38 highest *p*-dichlorobenzene concentrations measured across the program (those greater than 0.25 µg/m³), these two sites account for 29 of them (23 for PXSS and 13 for SPAZ). By comparison, the next highest site had three (S4MO).
- SPAZ and PXSS also has the third and fourth highest annual average concentrations of ethylbenzene, the fifth and sixth highest annual average concentrations of 1,3-butadiene; and the eighth and tenth highest annual average concentrations of benzene among NMP sites sampling these pollutants.
- PXSS has the highest fourth annual average concentration of acetaldehyde and the fifth highest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds.
- The annual average concentration of naphthalene for PXSS ranks seventh among NMP sites sampling PAHs.
- Even though arsenic is a pollutant of interest for PXSS, this site does not appear in Table 4-12 for arsenic (it ranked 11th). However, PXSS ranks third highest for nickel among NMP sites sampling PM₁₀ metals, similar to 2012.

6.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 6-4 for PXSS and SPAZ. Figures 6-6 through 6-15 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 6-6. Program vs. Site-Specific Average Acetaldehyde Concentration

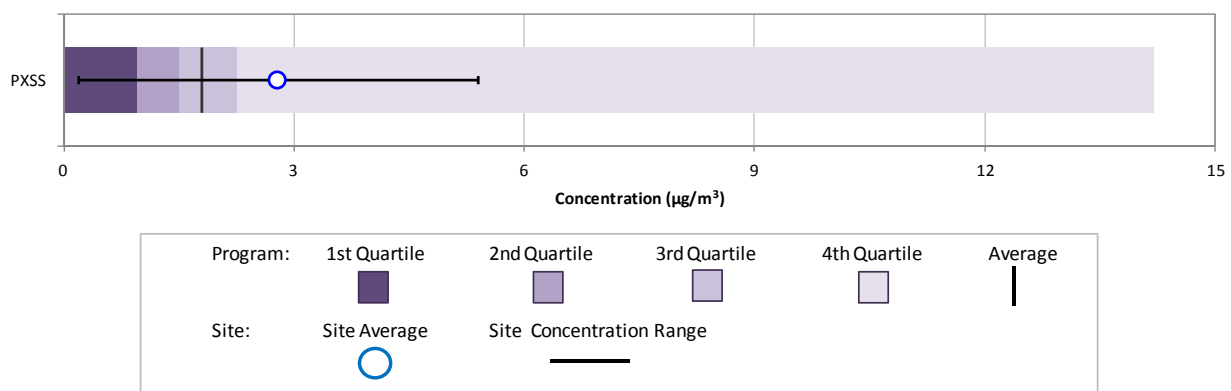


Figure 6-7. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

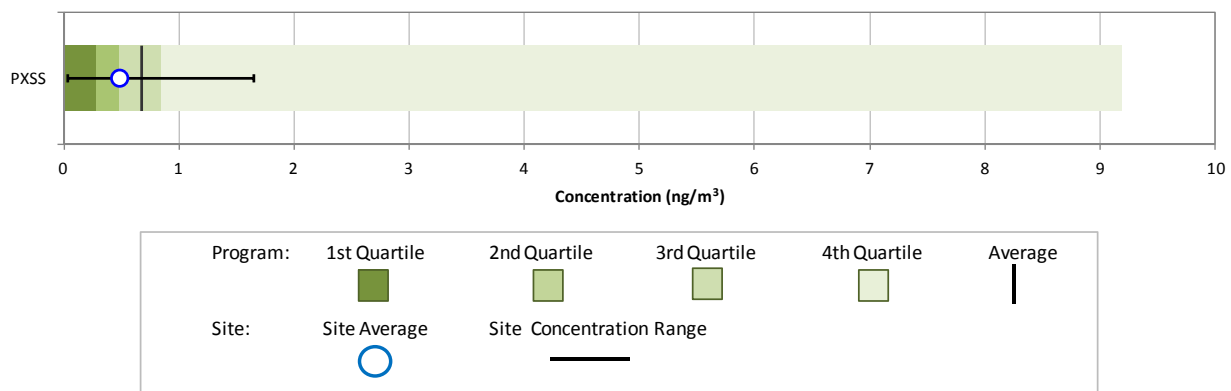


Figure 6-8. Program vs. Site-Specific Average Benzene Concentrations

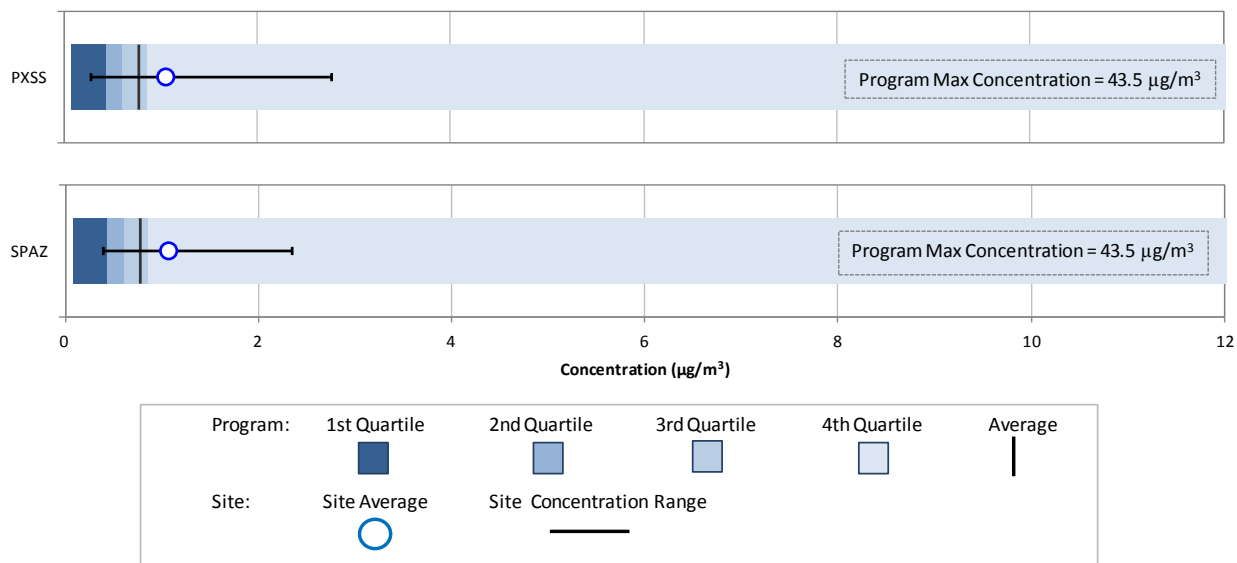


Figure 6-9. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

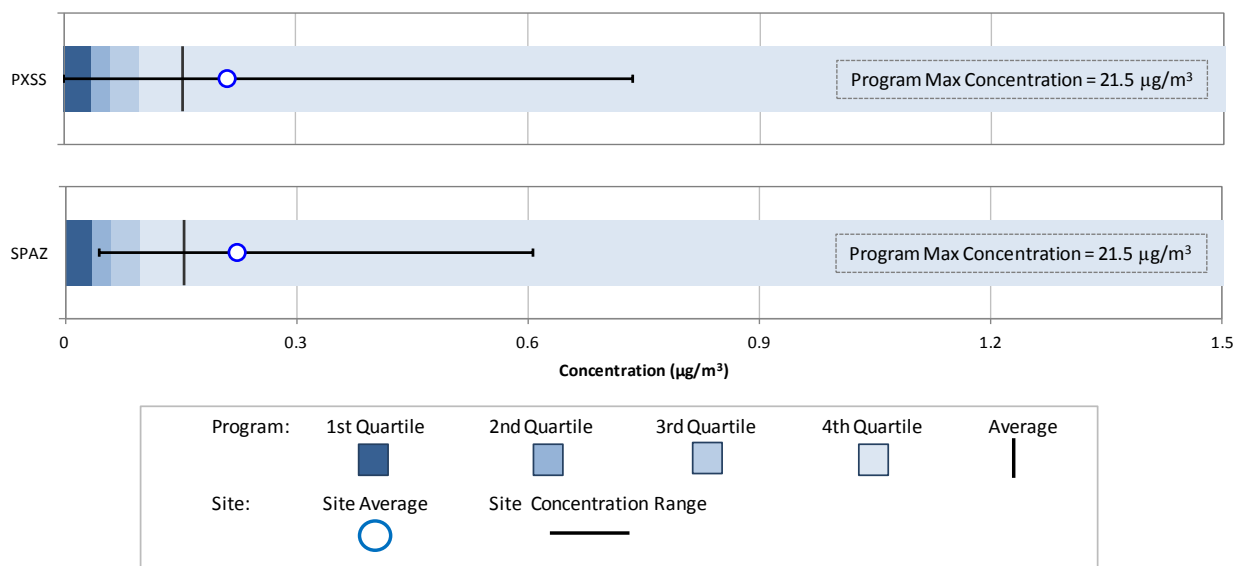


Figure 6-10. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations

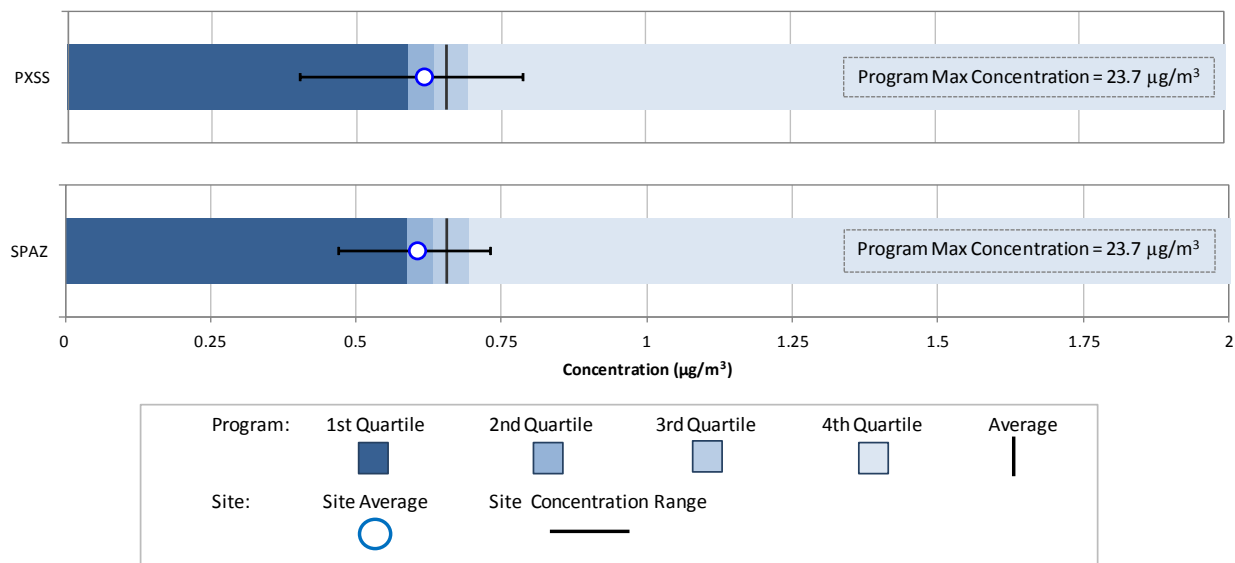


Figure 6-11. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentrations

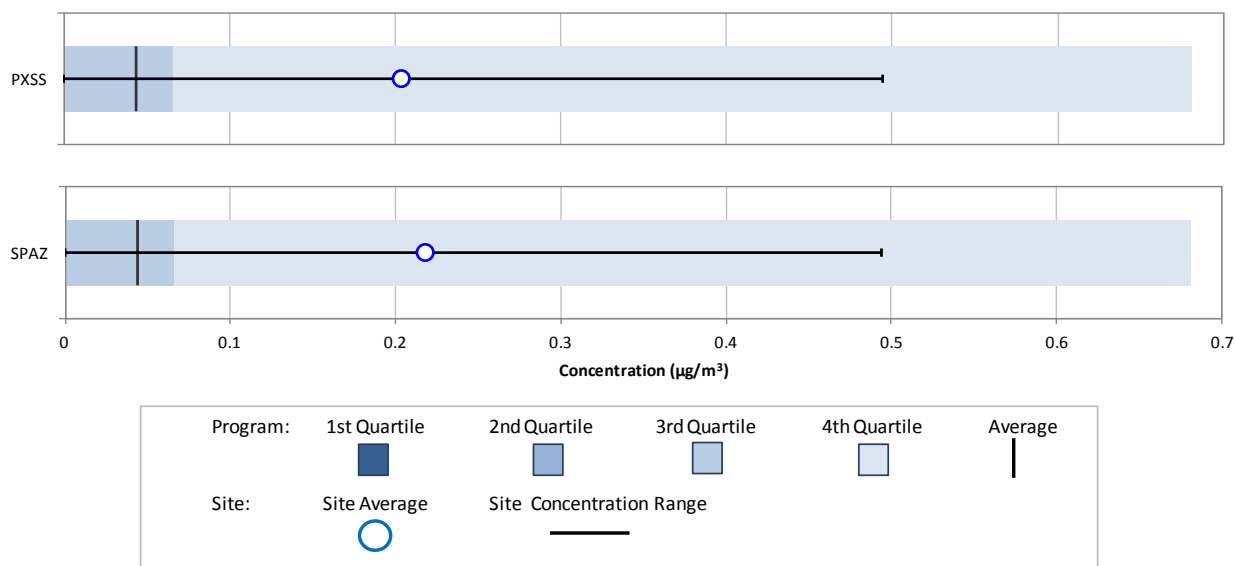


Figure 6-12. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations

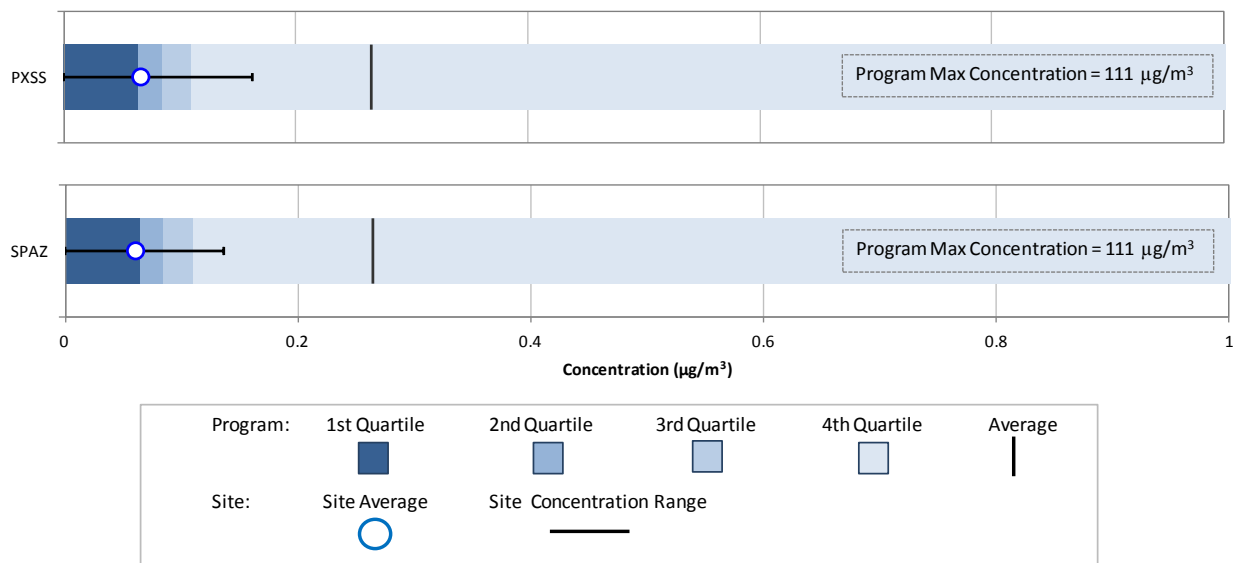


Figure 6-13. Program vs. Site-Specific Average Ethylbenzene Concentrations

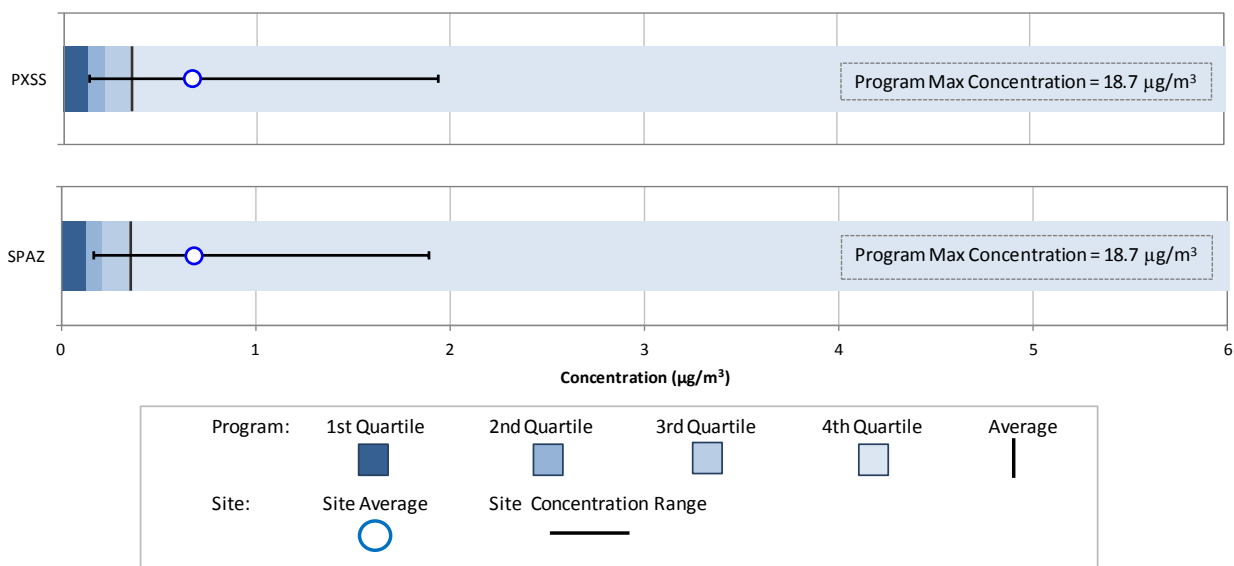


Figure 6-14. Program vs. Site-Specific Average Formaldehyde Concentration

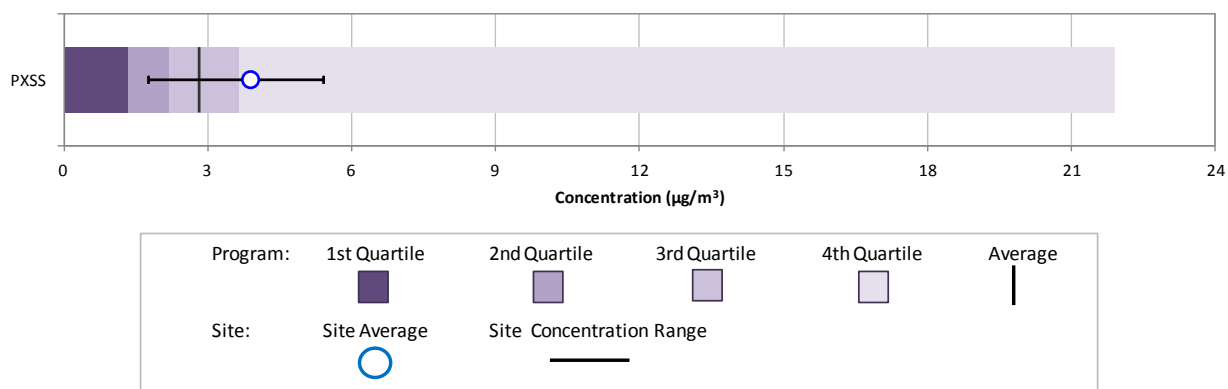
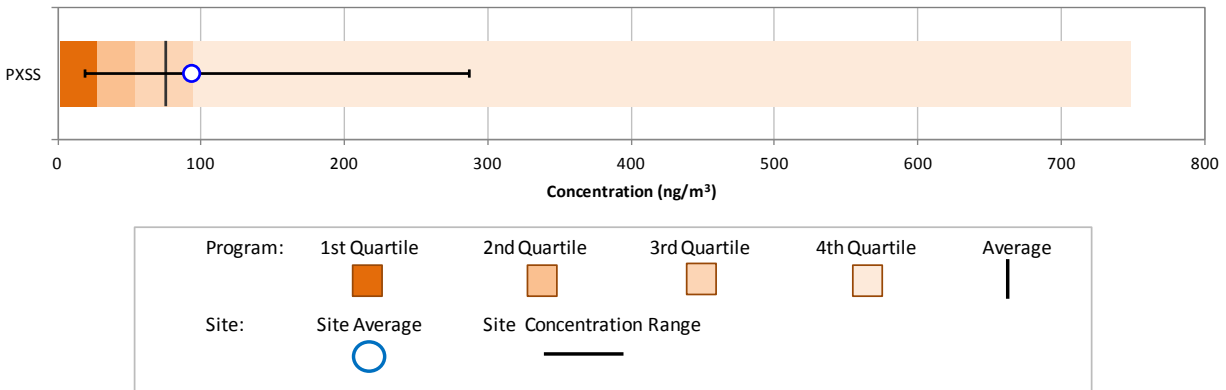


Figure 6-15. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 6-6 through 6-15 include the following:

- Figure 6-6 for acetaldehyde shows that PXSS's annual average concentration of nearly $3 \mu\text{g}/\text{m}^3$ is greater than the program-level average concentration as well as the program-level third quartile. Recall from the previous section that PXSS has the fourth highest annual average concentration among NMP sites sampling this pollutant, although the maximum acetaldehyde concentration measured at PXSS is considerably less than the maximum concentration measured across the program.
- Figure 6-7 shows that the annual average arsenic (PM_{10}) concentration for PXSS is less than the program-level average concentration for arsenic (PM_{10}) and is similar to the program-level median concentration. Arsenic concentrations measured at PXSS range from $0.03 \text{ ng}/\text{m}^3$ to $1.66 \text{ ng}/\text{m}^3$.
- The program-level maximum benzene concentration ($43.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots in Figure 6-8 because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plots has been reduced to $12 \mu\text{g}/\text{m}^3$. Figure 6-8 for benzene shows both Arizona sites, as both SPAZ and PXSS sampled VOCs. Although the maximum benzene concentration measured at each Arizona site is considerably less than the maximum benzene concentration measured across the program, both sites' annual averages are greater than the program-level average concentration. The annual average benzene concentration for these sites are very similar to each other, although the range of measurements is greater for PXSS. The minimum benzene concentration measured at SPAZ is just less than the program-level first quartile.
- Similar to benzene, the program-level maximum 1,3-butadiene concentration ($21.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots in Figure 6-9 because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plots has been reduced to $1.5 \mu\text{g}/\text{m}^3$. Figure 6-9 for 1,3-butadiene also shows both sites. The range of 1,3-butadiene measurements is greater for PXSS than SPAZ, although the annual average concentrations are similar to each other. The annual average

concentrations for both sites are slightly greater than the program-level average concentration. The minimum 1,3-butadiene concentration measured at SPAZ is greater than the program-level first quartile. A single non-detect was measured at PXSS.

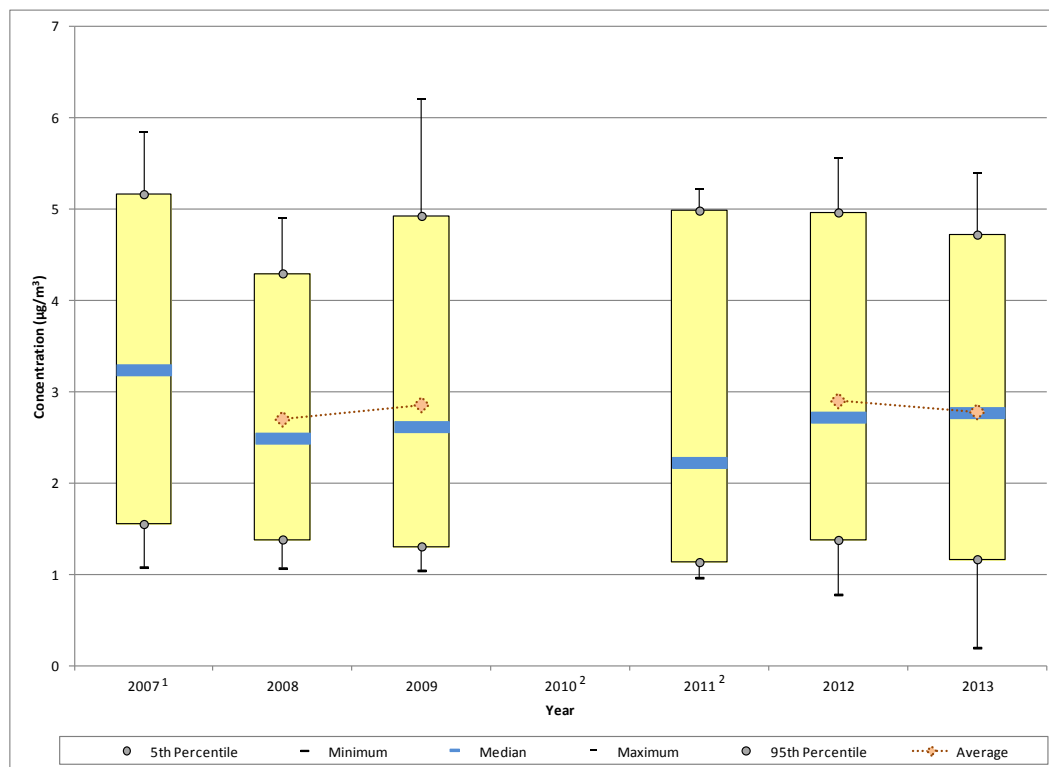
- Figure 6-10 presents the box plots for carbon tetrachloride for both sites. The scale of the box plots in Figure 6-10 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum carbon tetrachloride concentration ($23.75 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Figure 6-10 shows that the annual average concentrations of carbon tetrachloride for both Arizona sites are less than the program-level average and median concentrations. The range of concentrations measured at SPAZ is less than the range for PXSS.
- Figure 6-11 presents the box plots for *p*-dichlorobenzene for both sites. Note that the program-level first and second quartiles are both zero and therefore not visible on the box plots. SPAZ and PXSS have the highest annual average concentrations of *p*-dichlorobenzene among NMP sites sampling VOCs. The annual averages for SPAZ and PXSS are nearly five times the program-level average concentration. Although the maximum concentrations measured at these sites are less than the maximum concentration measured across the program, these two sites share the second highest concentrations measured across the program ($0.494 \mu\text{g}/\text{m}^3$, both of which were measured on the same day, October 19, 2013). A single non-detect of *p*-dichlorobenzene was measured at SPAZ while three non-detects were measured at PXSS.
- The scale of the box plots in Figure 6-12 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum 1,2-dichloroethane concentration ($111 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Note that all of the concentrations of 1,2-dichloroethane measured at PXSS and SPAZ are less than the program-level average concentration of $0.26 \mu\text{g}/\text{m}^3$, which is being driven by the measurements at the upper end of the concentration range. The annual average concentrations for PXSS and SPAZ are similar to the program-level first quartile of $0.065 \mu\text{g}/\text{m}^3$.
- The scale of the box plots in Figure 6-13 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum ethylbenzene concentration ($18.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Figure 6-13 show that the range and annual average concentrations of ethylbenzene for SPAZ and PXSS are similar to each other. The annual average concentrations of ethylbenzene for the two Arizona sites are roughly twice the program-level averages; recall from the previous section that these sites have the third and fourth highest annual average concentrations of ethylbenzene among NMP sites sampling this pollutant. The minimum ethylbenzene concentrations measured at PXSS and SPAZ are both greater than the program-level first quartile.

- Figure 6-14 is the box plot for formaldehyde for PXSS. This figure shows that the range of formaldehyde concentrations measured at PXSS falls within a relatively small range ($1.76 \mu\text{g}/\text{m}^3$ to $5.41 \mu\text{g}/\text{m}^3$) compared to the range of concentrations measured across the program. However, the annual average concentration for PXSS is greater than both the program-level average concentration and third quartile. Recall from the previous section that this site has the fifth highest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds.
- Figure 6-15 is the box plot for naphthalene for PXSS. Figure 6-15 shows that the annual average naphthalene concentration for PXSS is just less than $100 \text{ ng}/\text{m}^3$, which is greater than the program-level average concentration ($75.26 \text{ ng}/\text{m}^3$) and similar to the program-level third quartile ($94.65 \text{ ng}/\text{m}^3$). However, the maximum naphthalene concentration measured at PXSS ($287 \text{ ng}/\text{m}^3$) is considerably less than the maximum concentration measured at the program-level ($748 \text{ ng}/\text{m}^3$).

6.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. PXSS has sampled PM_{10} metals under the NMP since 2006; in addition, SPAZ began sampling VOCs and PXSS began sampling VOCs, carbonyl compounds, and PAHs under the NMP in 2007. Thus, Figures 6-16 through 6-31 present the 1-year statistical metrics for each of the pollutants of interest first for PXSS, then for SPAZ. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 6-16. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at PXSS



¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

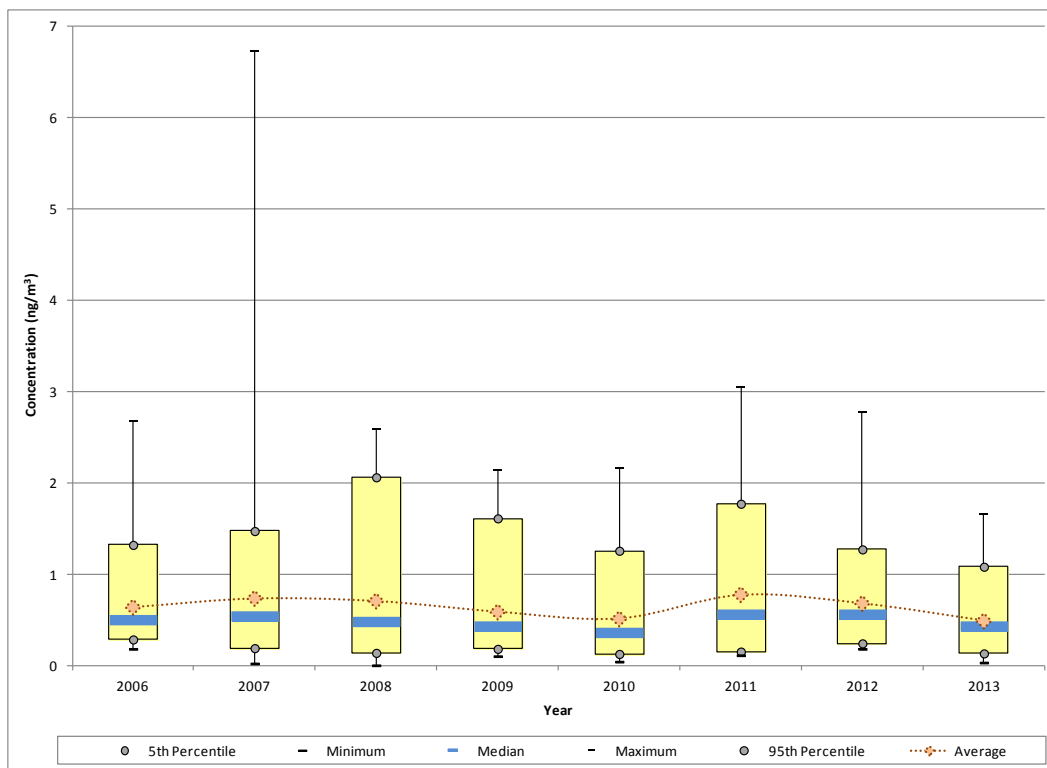
² Some statistical metrics are not presented because data from Feb 2010 to March 2011 was invalidated.

Observations from Figure 6-16 for acetaldehyde measurements collected at PXSS include the following:

- PXSS began sampling acetaldehyde under the NMP in July 2007. Because a full year's worth of data is not available, a 1-year average for 2007 is not presented, although the range of measurements is provided. In addition, much of the data between February 2010 and March 2011 was invalidated due to sampler maintenance issues on the primary sampler. No statistical metrics are provided for 2010 due to the low number of valid measurements. The range of measurements is provided for 2011, although a 1-year average is not provided.
- The maximum acetaldehyde concentration ($6.21 \mu\text{g}/\text{m}^3$) was measured on January 1, 2009, although this measurement is not significantly higher than the maximum concentrations measured in other years.
- A distinct trend is hard to identify because few 1-year averages are shown. However, the range of measurements has not changed much over the years. The median concentrations have varied from $2.23 \mu\text{g}/\text{m}^3$ (2011) to $3.24 \mu\text{g}/\text{m}^3$ (2007).
- The minimum concentration has decreased slightly every year, but considerably so for 2013. This minimum concentration ($0.20 \mu\text{g}/\text{m}^3$) was measured on July 21, 2013.

and is oddly low for PXSS. This is not reflected in the formaldehyde concentrations measured in this sample.

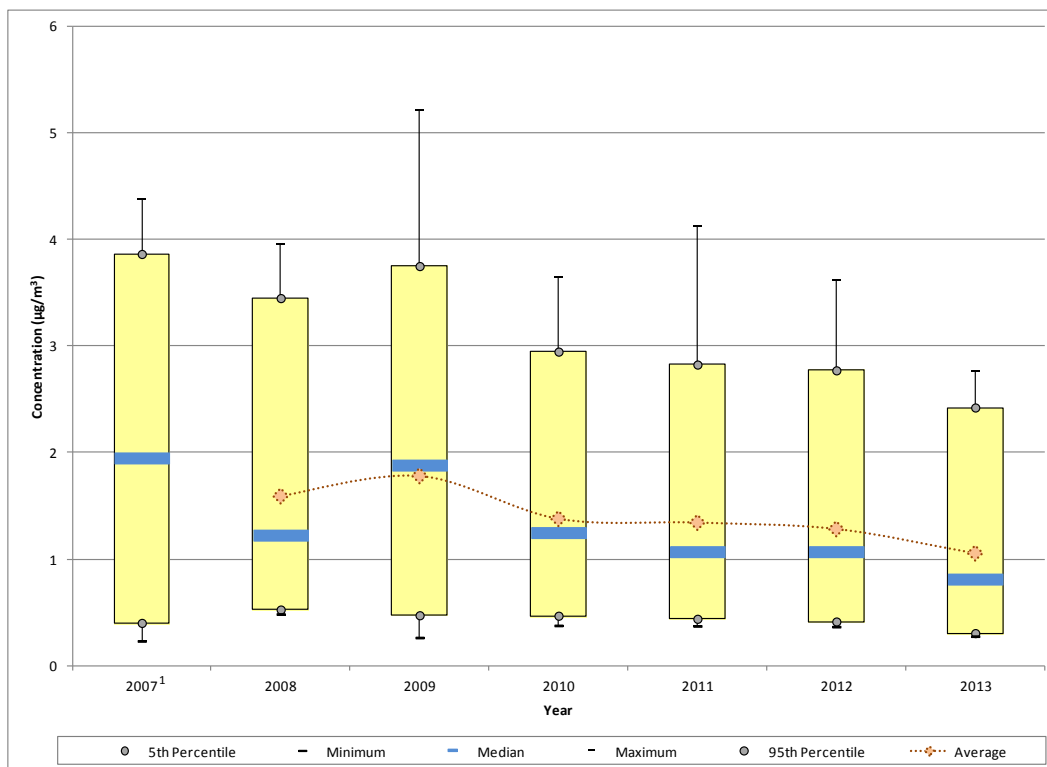
Figure 6-17. Yearly Statistical Metrics for Arsenic (PM₁₀) Concentrations Measured at PXSS



Observations from Figure 6-17 for arsenic measurements collected at PXSS include the following:

- PXSS began sampling arsenic under the NMP in January 2006.
- The maximum arsenic concentration (6.73 ng/m³) was measured on December 26, 2007 and is more than twice the next highest concentration (3.05 ng/m³), measured on August 19, 2011.
- After several years of a slight decreasing trend, the 1-year average concentration increased significantly from 2010 to 2011, after which a decreasing trend resumed. The 1-year average concentration for 2013 (0.49 ng/m³) is the lowest one shown in Figure 6-17.
- The range of arsenic concentrations measured at PXSS is the smallest for 2013, with less than 2 ng/m³ separating the minimum and maximum concentration measured. Less than 1 ng/m³ separates the 5th and 95th percentiles for 2013. The difference between the 1-year average and median concentrations for 2013 is less than 0.1 ng/m³. All of these metrics indicate a reduced level of variability in the arsenic concentrations measured in 2013 compared to previous years of sampling.

Figure 6-18. Yearly Statistical Metrics for Benzene Concentrations Measured at PXSS



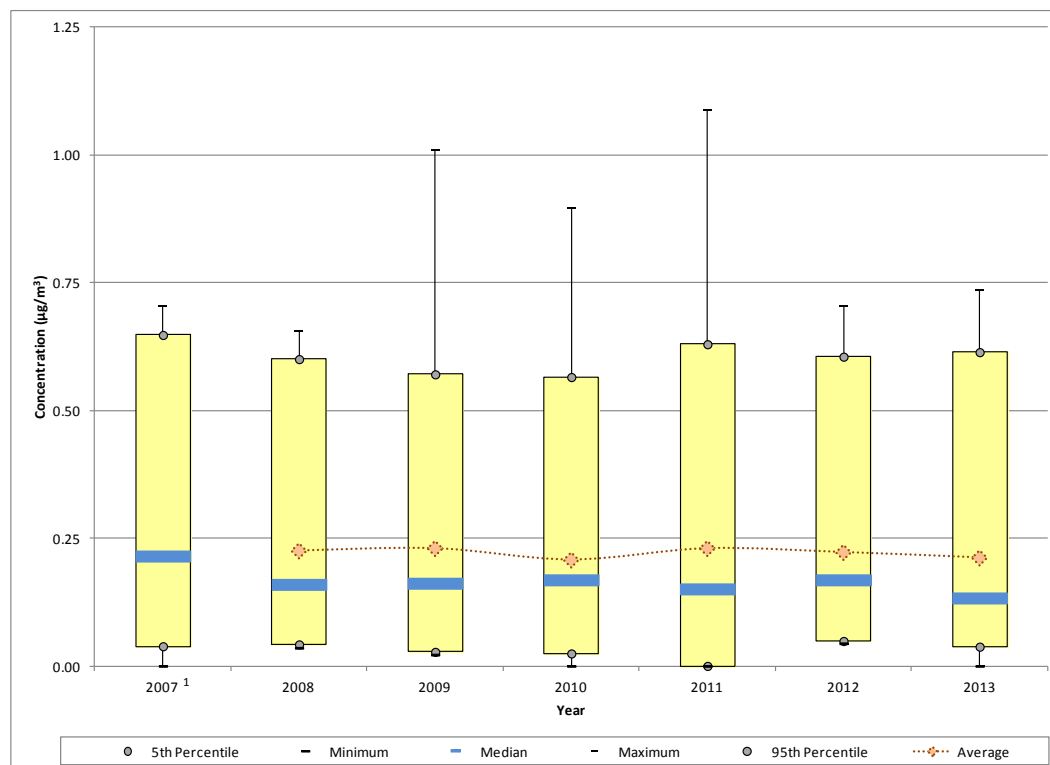
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-18 for benzene measurements collected at PXSS include the following:

- PXSS began sampling VOCs under the NMP in July 2007. Because a full year's worth of data is not available, a 1-year average for 2007 is not presented, although the range of measurements is provided.
- The maximum benzene concentration shown was measured on January 1, 2009 (5.21 $\mu\text{g}/\text{m}^3$). Only three additional measurements greater than 4 $\mu\text{g}/\text{m}^3$ have been measured at this site (one each in 2007, 2009, and 2011).
- The 15 highest benzene concentrations (those greater than 3.5 $\mu\text{g}/\text{m}^3$) were all measured in the first or fourth quarter of any given year. Further, of the 99 benzene concentrations greater than 2 $\mu\text{g}/\text{m}^3$, all but 10 were measured during the first or fourth quarters of a given year; those other 10 were all measured in either April or September, or just outside the first or fourth quarters.
- The median concentration increased significantly from 2008 to 2009 and is greater than the 1-year average concentration for 2009. A review of the data shows that the number of concentrations greater than 2 $\mu\text{g}/\text{m}^3$ increased from 15 to 24 from 2008 to 2009. For 2010, the number of benzene concentrations greater than 2 $\mu\text{g}/\text{m}^3$ decreased to 12.

- After the increase from 2008 to 2009, the 1-year average benzene concentration has a decreasing trend, with the largest change from 2009 to 2010. The 1-year average concentration for 2013 is the minimum average concentration shown in Figure 6-18. This is also true for the median concentration; 2013 is the first year for which the median concentration of benzene is less than $1 \mu\text{g}/\text{m}^3$.

Figure 6-19. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at PXSS



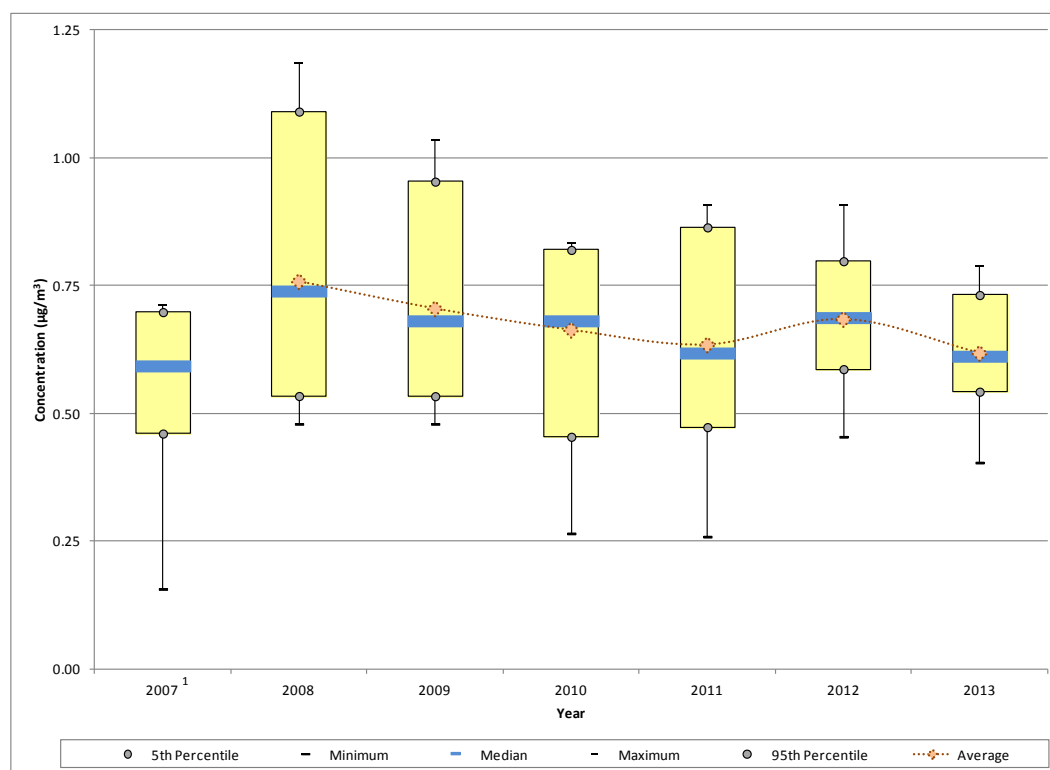
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-19 for 1,3-butadiene measurements collected at PXSS include the following:

- The maximum 1,3-butadiene concentration ($1.09 \mu\text{g}/\text{m}^3$) was measured on December 11, 2011. The only other concentration greater than $1.0 \mu\text{g}/\text{m}^3$ was measured at PXSS on January 1, 2009. All but two of the 103 concentrations greater than $0.30 \mu\text{g}/\text{m}^3$ were measured during the first or fourth quarters, supporting the observations regarding the trend in the quarterly averages discussed in the previous sections and Section 4.4.2. The two not measured in the first or fourth quarters were measured in September.
- The 1-year average 1,3-butadiene concentrations exhibit little change over the periods shown, ranging from $0.207 \mu\text{g}/\text{m}^3$ (2010) to $0.230 \mu\text{g}/\text{m}^3$ (both 2009 and 2011). The median concentration exhibits a similar consistency in magnitude, although the median concentration for 2013 is the minimum shown ($0.13 \mu\text{g}/\text{m}^3$).

- There have been nine non-detects of 1,3-butadiene measured at PXSS since the onset of VOC sampling at PXSS under the NMP. Five of these were measured in 2011, with one measured in 2007, two measured in 2010, and one measured in 2013. For 2011, the minimum and 5th percentile were both equal to zero. None of the non-detects of 1,3-butadiene were measured during the first or fourth quarters of the year.

Figure 6-20. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at PXSS



¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

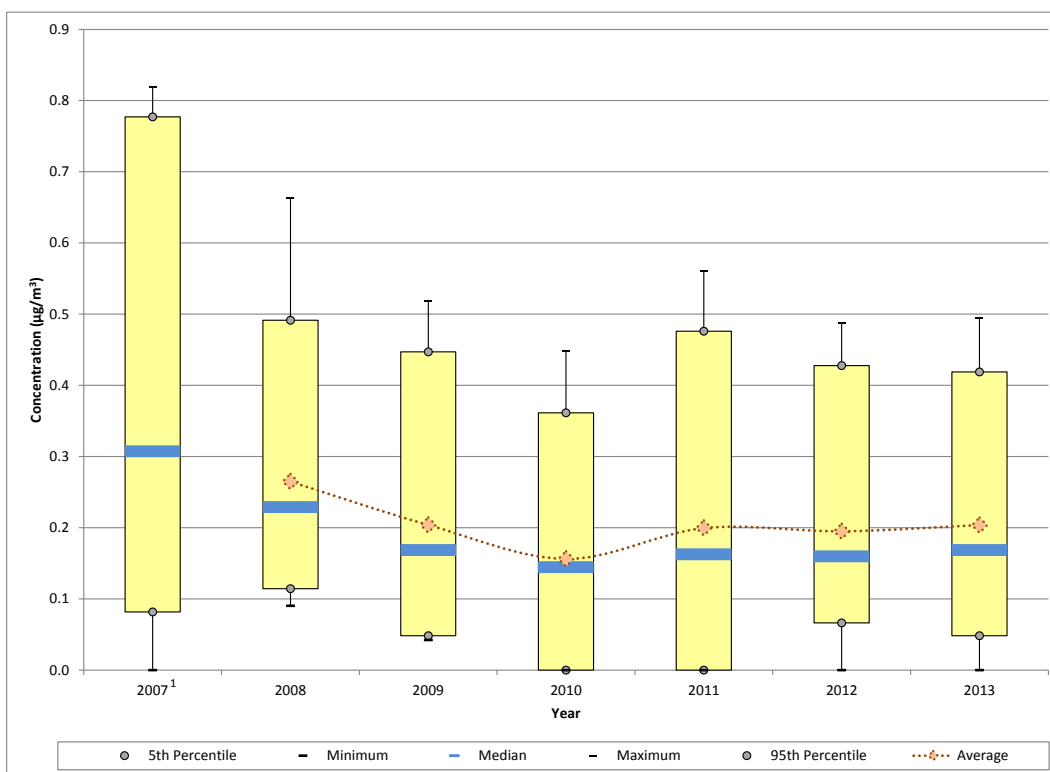
Observations from Figure 6-20 for carbon tetrachloride measurements collected at PXSS include the following:

- Seven concentrations of carbon tetrachloride greater than 1.0 µg/m³ have been measured at PXSS since the onset of sampling in 2007, with five measured in 2008 and two measured in 2009.
- For 2007, 2010, and 2011, the box and whisker plots for this pollutant appear “inverted,” with the minimum concentration extending farther away from the majority of the measurements rather than the maximum, which is more common (see benzene or 1,3-butadiene as examples).
- The 1-year average concentration exhibits a decreasing trend through 2011. Although the range of concentrations measured decreased for 2012, an increase is shown for the 1-year average and median concentrations for 2012. This is mostly a result of a

change at the lower end of the concentration range. The number of concentrations less than $0.6 \mu\text{g}/\text{m}^3$ in 2011 was 24; the number of concentrations less than $0.6 \mu\text{g}/\text{m}^3$ in 2012 was six. In addition, the maximum concentration measured is the same for both years yet the 95th percentile exhibits a decrease from 2011 to 2012.

- All of the statistical parameters for carbon tetrachloride exhibit a decrease for 2013.

Figure 6-21. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at PXSS



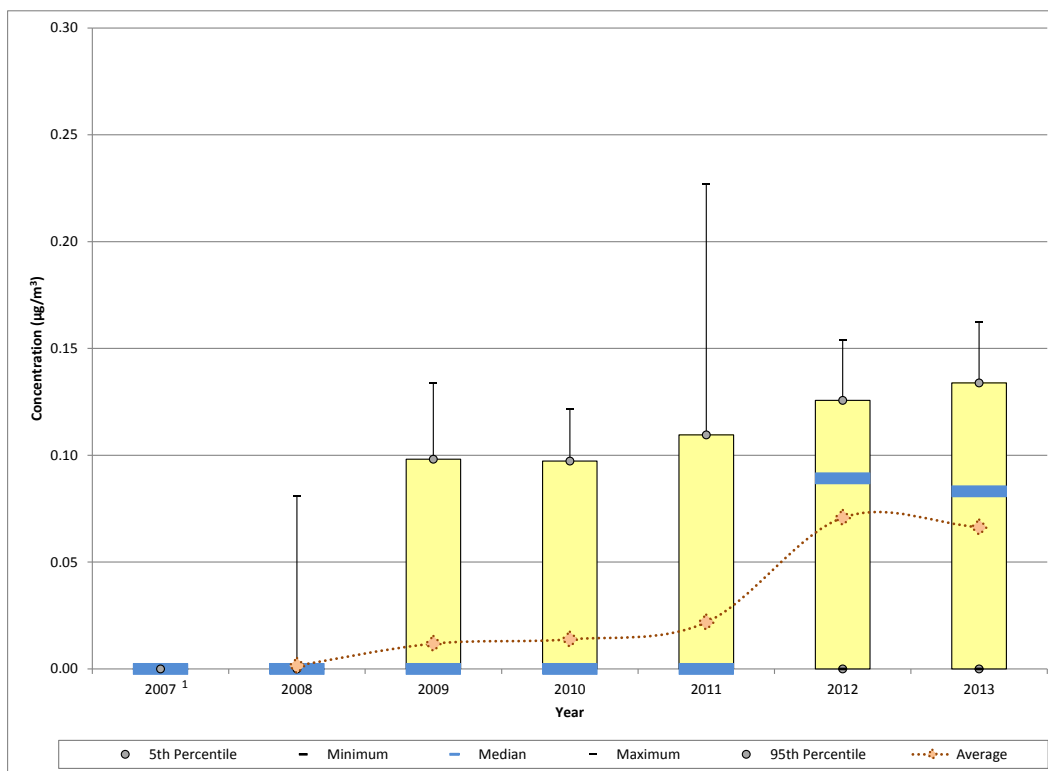
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-21 for *p*-dichlorobenzene measurements collected at PXSS include the following:

- The three highest concentrations of *p*-dichlorobenzene were all measured in November 2007.
- The maximum, 95th percentile, 1-year average, and median concentrations all exhibit a significant decreasing trend through 2010. Even the minimum concentration and 5th percentile decreased from 2008 through 2010. Prior to 2010, a single non-detect was measured; for 2010, nine non-detects were measured. Each of the statistical parameters increased for 2011, with the exception of the minimum and 5th percentile, as six additional non-detects were measured in 2011. One non-detect was measured in 2012 and three were measured in 2013.

- Although the range of measurements within which the majority of the concentrations fall tightened up for 2012, little change is shown for the 1-year average or median concentrations from 2011 to 2012. This is also true for 2013.

Figure 6-22. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at PXSS



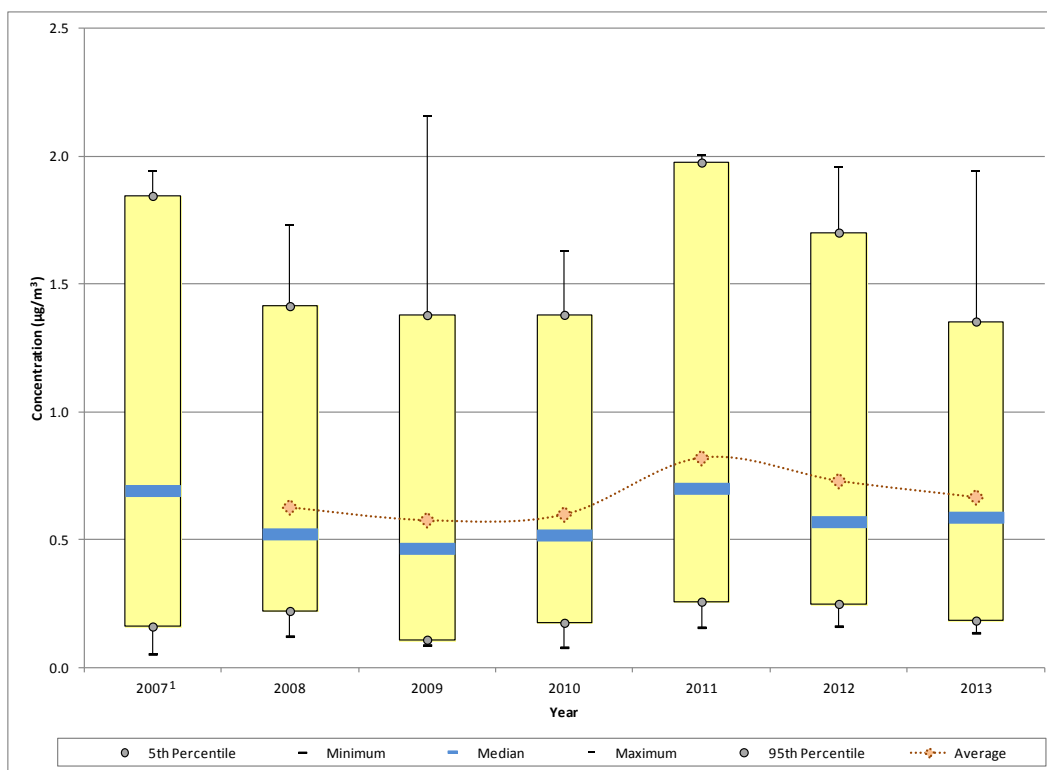
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-22 for 1,2-dichloroethane measurements collected at PXSS include the following:

- There were no measured detections of 1,2-dichloroethane in 2007, one measured detection in 2008, seven in 2009, nine in 2010, 12 in 2011, 47 in 2012, and 38 in 2013.
- The median concentration is zero for all years except 2012 and 2013, indicating that at least 50 percent of the measurements were non-detects for the first 5 years of sampling.
- As the number of measured detections increase, so do the corresponding statistical metrics shown in Figure 6-22.
- The number of measured detections increased dramatically for 2012, and the median and 1-year average concentrations increased correspondingly. The median concentration is greater than the 1-year average for both 2012 and 2013. This is because there were still many non-detects (or zeros) factoring into the 1-year average

concentration for 2012 (14) and 2013 (23), which drive the 1-year averages down in the same manner that a maximum or outlier concentration can drive the average up.

Figure 6-23. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at PXSS



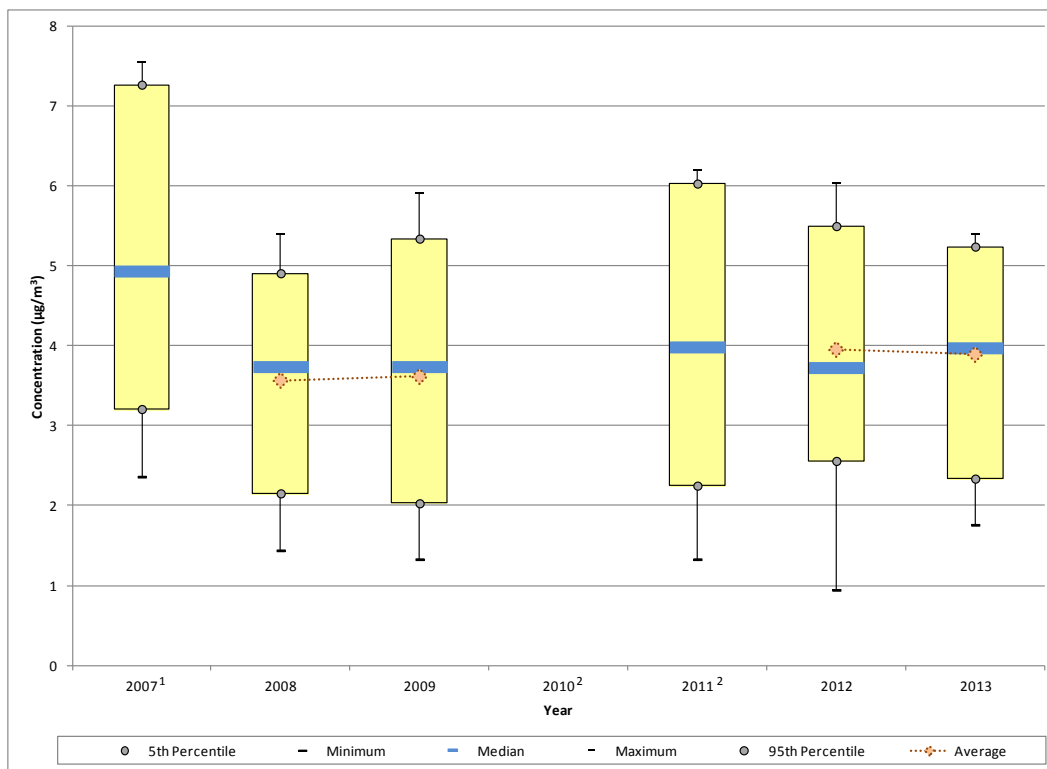
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-23 for ethylbenzene measurements collected at PXSS include the following:

- The maximum concentration of ethylbenzene measured at PXSS ($2.16 \mu\text{g}/\text{m}^3$) was measured on January 1, 2009. The next four highest concentrations were all measured in November 2011, including the only other concentration greater than $2 \mu\text{g}/\text{m}^3$ that has been measured at PXSS ($2.01 \mu\text{g}/\text{m}^3$).
- Similar to 1,3-butadiene, the highest ethylbenzene concentrations were measured during the first and fourth quarters of the years. All but one of the 33 highest concentrations (those greater than $1.40 \mu\text{g}/\text{m}^3$) were measured between January and March or October and December of any given year. The one exception was measured in September.
- The median ethylbenzene concentration has a decreasing trend through 2009, then returns to 2008 levels for 2010. All of the statistical parameters shown increased from 2010 to 2011. Nearly twice the number of measurements greater than $1 \mu\text{g}/\text{m}^3$ were measured in 2011 (20) than the previous years (11 or less).

- Although the range of measurements changed little, the 1-year average, median, and 95th percentile decreased from 2011 to 2012. Further decreases are shown for 2013, except for the median, which increased slightly.

Figure 6-24. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at PXSS



¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

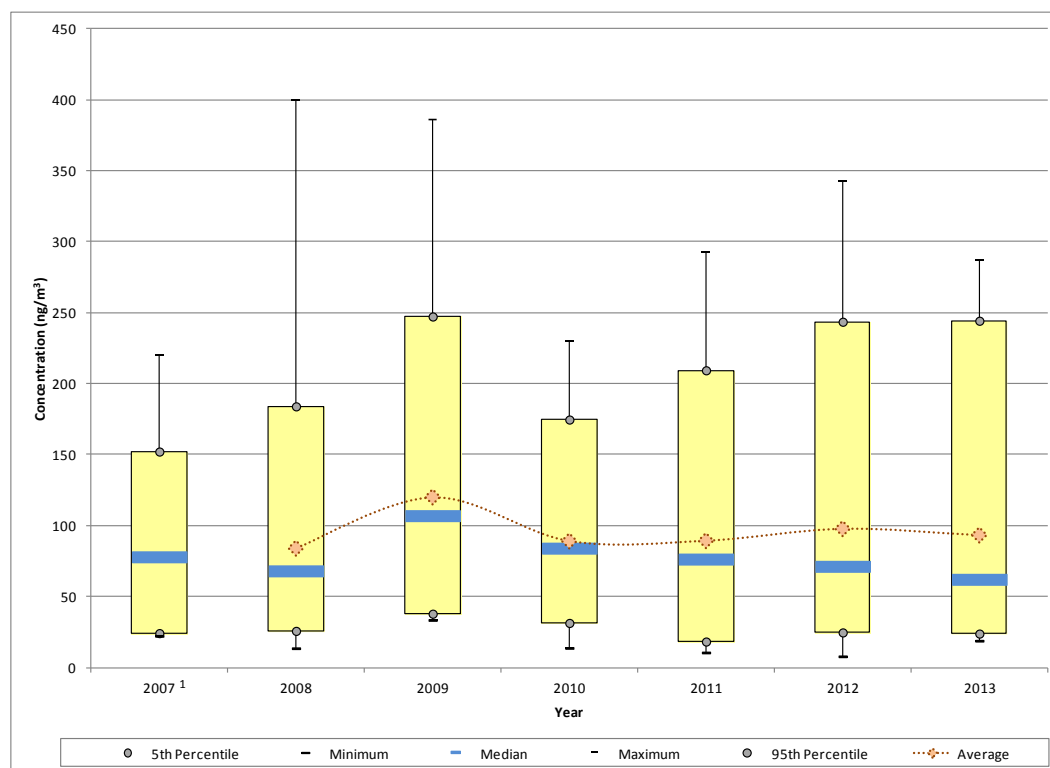
² Some statistical metrics are not presented because data from Feb 2010 to March 2011 was invalidated.

Observations from Figure 6-24 for formaldehyde measurements collected at PXSS include the following:

- PXSS began sampling formaldehyde under the NMP in July 2007. Because a full year's worth of data is not available, a 1-year average for 2007 is not presented, although the range of measurements is provided. In addition, much of the data between February 2010 and March 2011 was invalidated due to sampler maintenance issues on the primary sampler. No statistical metrics are provided for 2010 due to the low number of valid measurements. The range of measurements is provided for 2011, although a 1-year average is not provided.
- The five highest formaldehyde concentrations (ranging from 6.28 $\mu\text{g}/\text{m}^3$ to 7.55 $\mu\text{g}/\text{m}^3$) were all measured in 2007. The next five highest concentrations were all measured in either 2007 or 2011.
- The median concentration for 2007 is nearly 5 $\mu\text{g}/\text{m}^3$. The median concentration for the years that follow are all less than 4 $\mu\text{g}/\text{m}^3$.

- Only one formaldehyde concentration less than $1 \mu\text{g}/\text{m}^3$ has been measured at PXSS (2012) and only 11 less than $2 \mu\text{g}/\text{m}^3$ have been measured since 2007.

Figure 6-25. Yearly Statistical Metrics for Naphthalene Concentrations Measured at PXSS



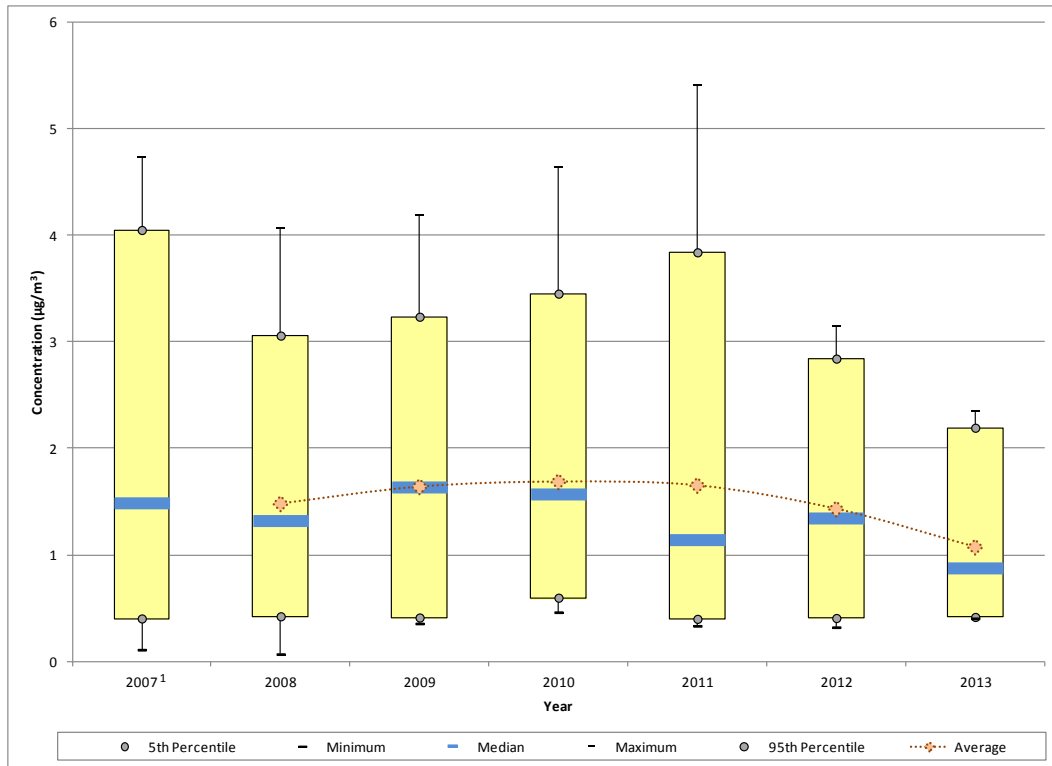
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-25 for naphthalene measurements collected at PXSS include the following:

- PXSS began sampling PAHs under the NMP in July 2007.
- The maximum naphthalene concentration was measured in December 2008. Although this is the only measurement greater than $400 \text{ ng}/\text{m}^3$ measured at PXSS, a similar concentration was also measured 12 days later on January 1, 2009 ($386 \text{ ng}/\text{m}^3$). The only other measurement greater than $300 \text{ ng}/\text{m}^3$ was measured on December 23, 2012.
- Many of the statistical parameters are highest for 2009. The median, or midpoint, for 2009 is $107 \text{ ng}/\text{m}^3$. The median concentrations for the other years are less, ranging from $62.15 \text{ ng}/\text{m}^3$ (2013) to $84.1 \text{ ng}/\text{m}^3$ (2010).
- The difference between the 5th and 95th percentiles has an increasing trend between 2010 and 2012, indicating that the range of concentrations within which the majority of concentrations lie increased. This range did not change between 2012 and 2013. Conversely, the median concentration has a steady decreasing trend during this same

period. This is mostly a result of an increase in the number of concentrations at both the lower and higher magnitudes.

Figure 6-26. Yearly Statistical Metrics for Benzene Concentrations Measured at SPAZ



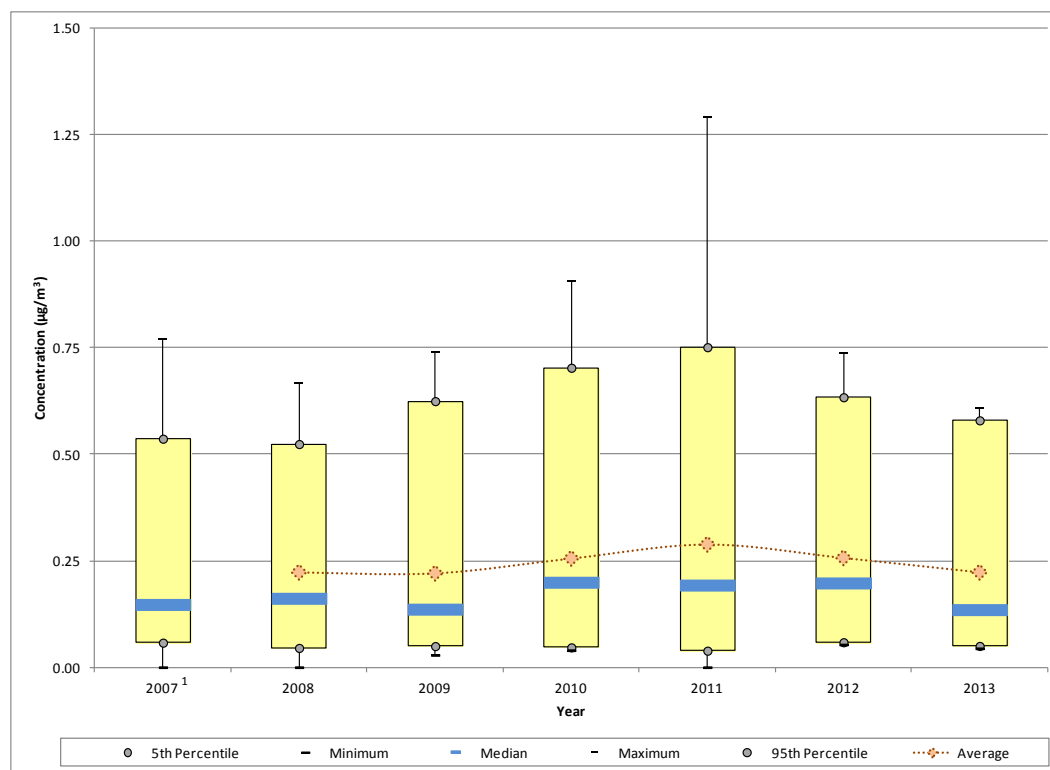
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-26 for benzene measurements collected at SPAZ include the following:

- SPAZ also began sampling VOCs under the NMP in July 2007. Because a full year's worth of data is not available, a 1-year average for 2007 is not presented, although the range of concentrations measured is provided.
- The maximum benzene concentration shown was measured on January 27, 2011 ($5.41 \mu\text{g}/\text{m}^3$) and is the only benzene concentration greater than $5 \mu\text{g}/\text{m}^3$ measured at SPAZ. Only five additional measurements greater than $4 \mu\text{g}/\text{m}^3$ have been measured at this site (one for each year of sampling except 2012 and 2013). Forty-eight of the 52 benzene concentrations greater than $2 \mu\text{g}/\text{m}^3$ were measured during the first or fourth quarters of any given year.
- After several years of increasing, both the maximum and 95th percentile decreased considerably for 2012 and again for 2013. The range of concentrations measured is at a minimum for 2013, spanning less than $2 \mu\text{g}/\text{m}^3$.

- The 1-year average concentrations changed little from 2009 through 2011, then decreased from 2011 to 2012 and again for 2013. The median concentration exhibits more variability during this time frame.

Figure 6-27. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at SPAZ



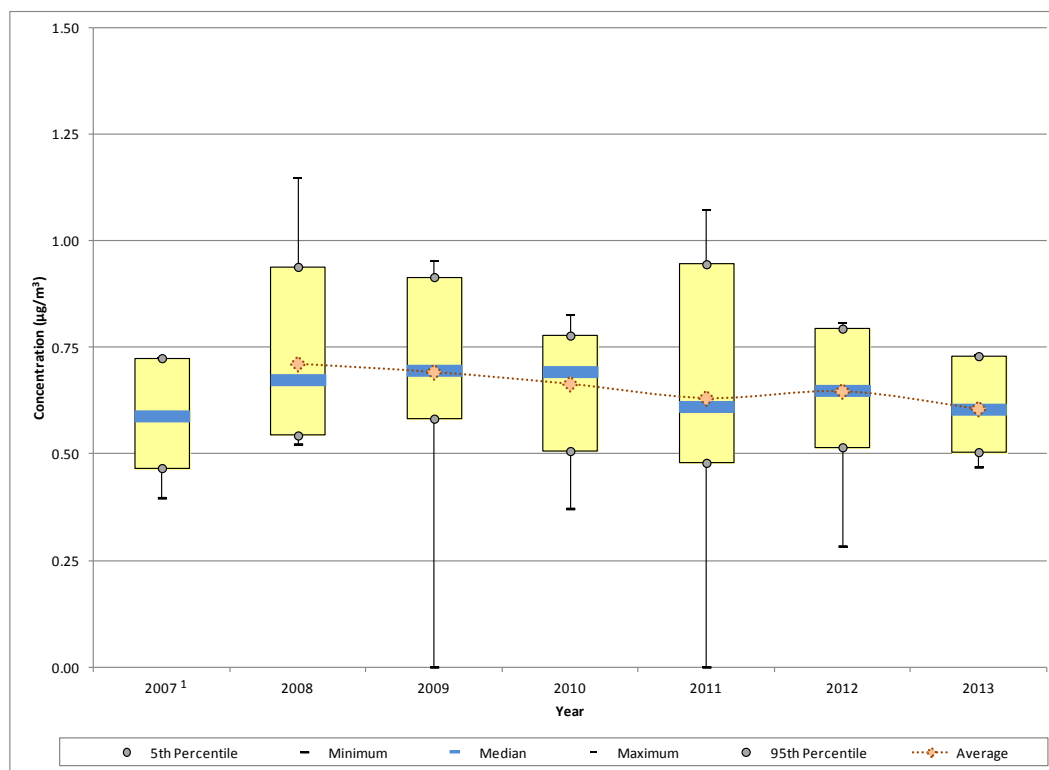
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-27 for 1,3-butadiene measurements collected at SPAZ include the following:

- The only 1,3-butadiene concentration greater than $1 \mu\text{g}/\text{m}^3$ was measured on January 27, 2011 ($1.29 \mu\text{g}/\text{m}^3$). Forty-five of the 47 concentrations greater than $0.35 \mu\text{g}/\text{m}^3$ were measured at SPAZ during the first or fourth quarters of any given year, similar to the trend seen in PXSS 1,3-butadiene measurements.
- The maximum concentration and 95th percentile increased each year after 2008 through 2011, while the 5th percentile remained fairly static. This indicates that more of the measurements collected were at the higher end of the concentration range for each of these years. For 2012, the maximum concentration and 95th percentiles are lower; with the maximum concentration for 2012 less than the 95th percentile for 2011. This is also true for 2013, where the maximum concentration is less than the 95th percentile for the preceding year. This is a pattern similar to that exhibited by benzene in Figure 6-26.
- The 1-year average concentrations exhibit a slight increasing trend between 2009 and 2011, followed by a return to 2010 levels for 2012 and 2008/2009 levels for 2013.

However, the 1-year averages vary by less than $0.1 \mu\text{g}/\text{m}^3$, ranging from $0.22 \mu\text{g}/\text{m}^3$ (2008, 2009, and 2013) to $0.29 \mu\text{g}/\text{m}^3$ (2011), and confidence intervals calculated indicate these changes are not statistically significant.

Figure 6-28. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at SPAZ



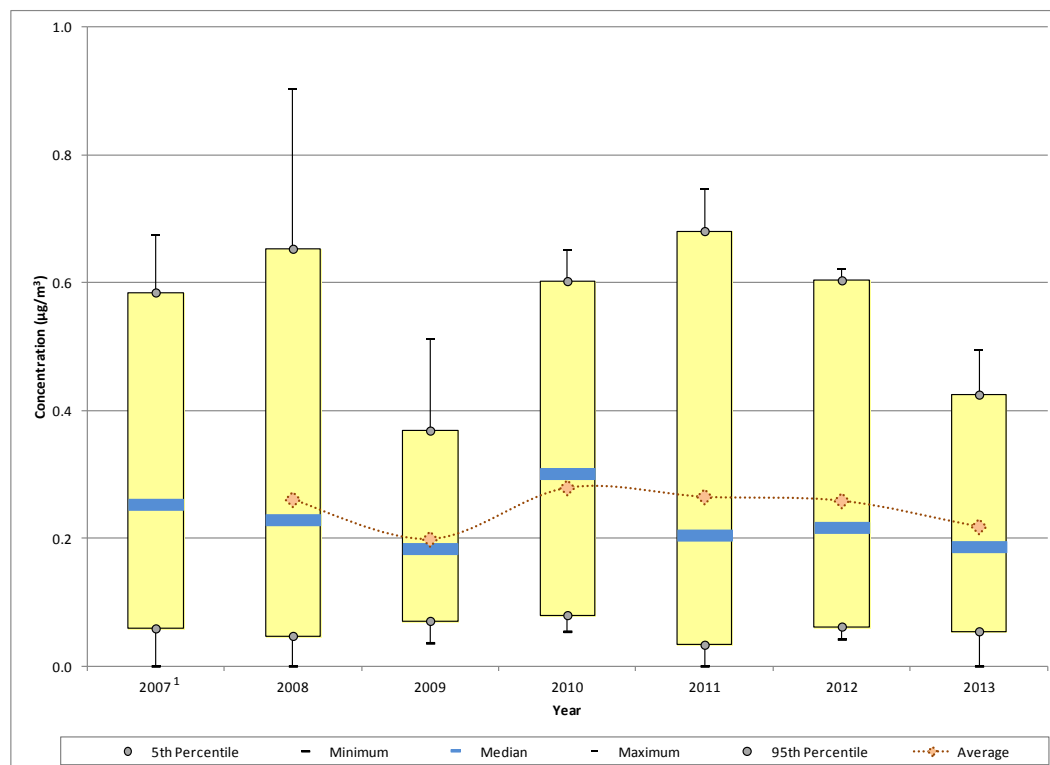
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-28 for carbon tetrachloride measurements collected at SPAZ include the following:

- Two concentrations of carbon tetrachloride greater than $1.0 \mu\text{g}/\text{m}^3$ have been measured at SPAZ since the onset of sampling in 2007. One was measured in 2008 and one was measured in 2011 (although another concentration just less than $1 \mu\text{g}/\text{m}^3$ was measured in 2011). Conversely, two non-detects of carbon tetrachloride have been measured at SPAZ, one in 2009 and one in 2011.
- For the years 2009 through 2012, the box and whisker plots for this pollutant appear “inverted,” with the minimum concentration extending farther away from the majority of the measurements for several years rather than the maximum (see benzene or 1,3-butadiene as examples), which is more common.
- With the exception of 2012, the 1-year average exhibits a slight decreasing trend. However, the differences represent an overall change of less than $0.11 \mu\text{g}/\text{m}^3$ and, based on the confidence intervals, are not statistically significant.

- The range of concentrations measured is at a minimum for 2013, as is the difference between the 1-year average and median for 2013 (less than $0.01 \mu\text{g}/\text{m}^3$), indicating the lowest level of variability in the measurements compared to other years. However, the difference between the 1-year average and median concentrations is relatively low for every year, with the difference for 2008 being the largest ($0.04 \mu\text{g}/\text{m}^3$).

Figure 6-29. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at SPAZ

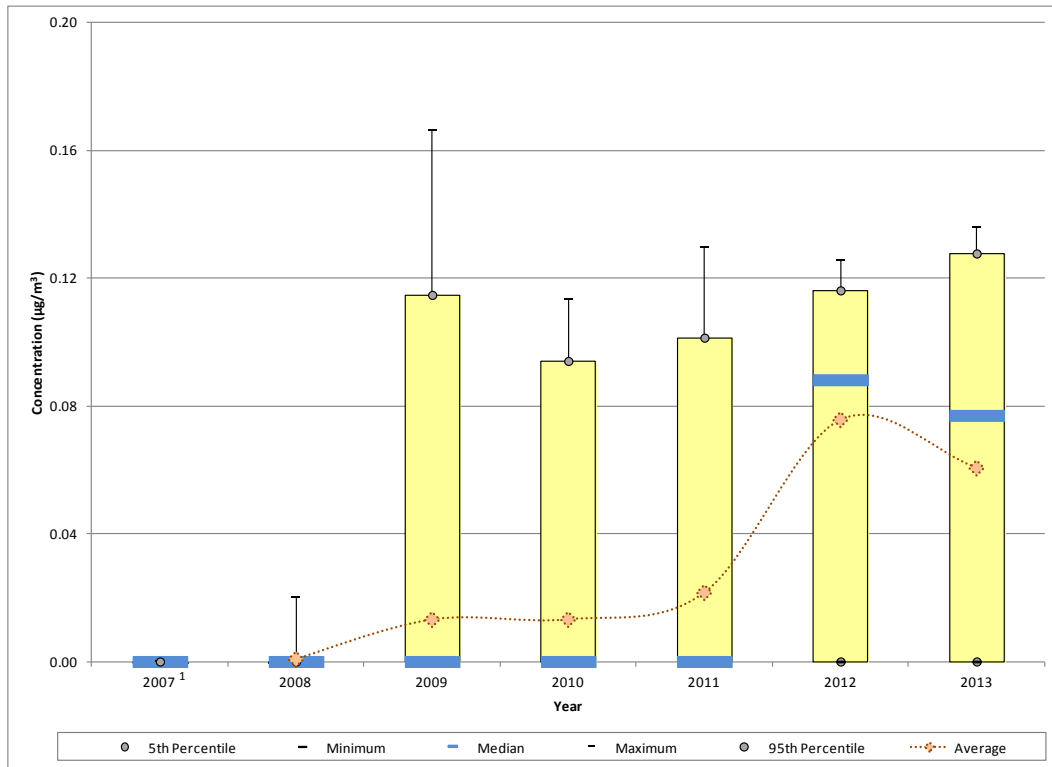


¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-29 for *p*-dichlorobenzene measurements collected at SPAZ include the following:

- The widest range of *p*-dichlorobenzene concentrations measured is shown for 2008 (non-detect to $0.90 \mu\text{g}/\text{m}^3$), while the smallest range is shown for the following year ($0.036 \mu\text{g}/\text{m}^3$ to $0.51 \mu\text{g}/\text{m}^3$).
- The 1-year average concentration decreased from 2008 to 2009, increased for 2010, then decreased slightly each year between 2011 and 2013. However, confidence intervals calculated for these averages indicate that the changes are not statistically significant. The median concentrations exhibit larger fluctuations than the 1-year average concentrations.

Figure 6-30. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at SPAZ

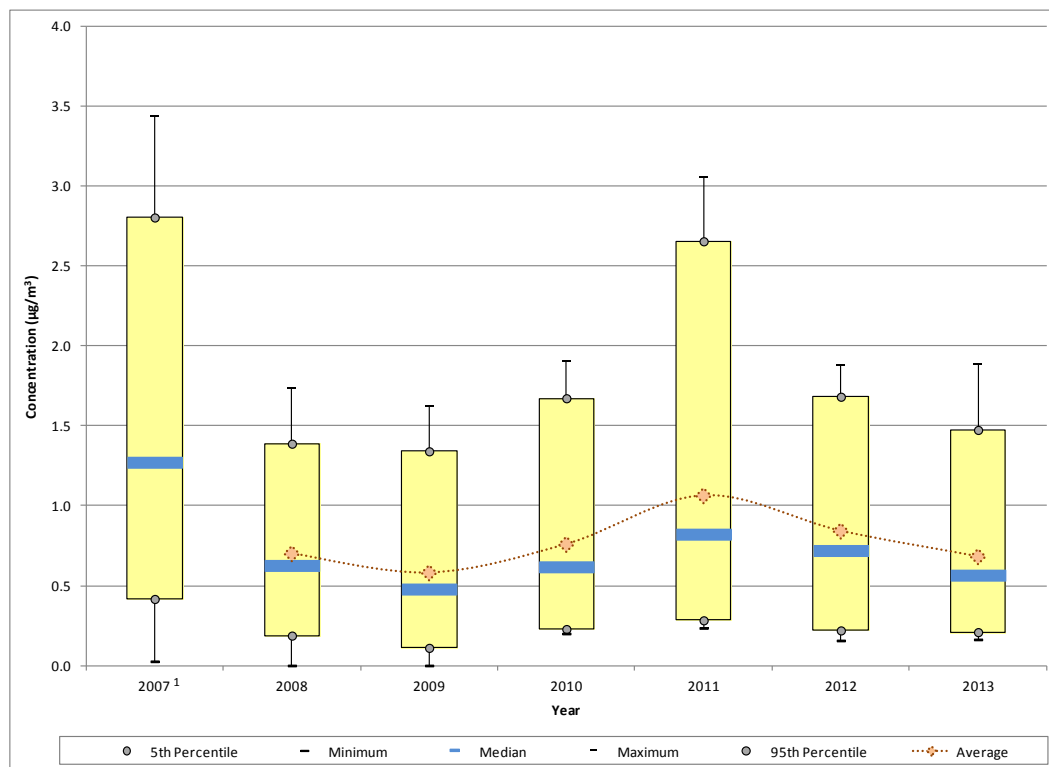


¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-30 for 1,2-dichloroethane measurements collected at SPAZ include the following:

- There were no measured detections of 1,2-dichloroethane in 2007, one measured detection in 2008, three in 2009, four in 2010, seven in 2011, 26 in 2012, and 19 in 2013.
- The median concentration is zero for all years until 2012, indicating that at least 50 percent of the measurements were non-detects.
- As the number of measured detections increase, so do the corresponding central tendency statistics shown in Figure 6-30.
- The median concentration is greater than the 1-year average concentration for 2012. This is because the four non-detects (or zeros) factored into the 1-year average concentration are pulling the average down in the same manner that a maximum or outlier concentration can pull the average up.
- Even though the range of concentrations measured increased for 2013, both the median concentration and the 1-year average concentration decreased. This is a result of the increase of the number of non-detects for 2013 (12) compared to 2012.

Figure 6-31. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at SPAZ



¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 6-31 for ethylbenzene measurements collected at SPAZ include the following:

- The maximum concentration of ethylbenzene measured at SPAZ ($3.44 \mu\text{g}/\text{m}^3$) was measured in 2007. The only other concentration greater than $3.0 \mu\text{g}/\text{m}^3$ was measured at SPAZ on January 27, 2011 ($3.06 \mu\text{g}/\text{m}^3$). All eight concentrations between $2.0 \mu\text{g}/\text{m}^3$ and $3.0 \mu\text{g}/\text{m}^3$ were measured in either 2007 (four) or 2011 (four).
- The median concentration is at a maximum for 2007, after which the median decreases by half. Recall that 2007 includes only half a year's worth of samples. The downward trend continues through 2009, followed by an increase that continues through 2011. The median decreases somewhat for 2012 and again in 2013. The 1-year average concentration has a similar pattern, although no 1-year average concentration is presented for 2007.
- The only non-detects of ethylbenzene were measured during the first full-years of sampling at SPAZ.

6.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at each Arizona monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

6.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Arizona monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 6-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Observations for PXSS from Table 6-6 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde, acetaldehyde, and benzene, and are the only pollutants of interest with annual average concentrations greater than 1 $\mu\text{g}/\text{m}^3$.
- Based on the annual averages and cancer UREs, formaldehyde has the highest cancer risk approximation (50.62 in-a-million), followed by benzene (8.23 in-a-million), 1,3-butadiene (6.34 in-a-million), and acetaldehyde (6.12 in-a-million).
- Formaldehyde's cancer risk approximation for PXSS is the sixth highest cancer risk approximation among all of the site-specific pollutants of interest across the program.
- None of the pollutants of interest for PXSS have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation for PXSS is formaldehyde (0.40). This noncancer hazard approximation is the eighth highest noncancer hazard approximation among all site-specific pollutants of interest.

Table 6-6. Risk Approximations for the Arizona Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Phoenix, Arizona - PXSS						
Acetaldehyde	0.0000022	0.009	60/60	2.78 ± 0.29	6.12	0.31
Benzene	0.0000078	0.03	61/61	1.06 ± 0.18	8.23	0.04
1,3-Butadiene	0.00003	0.002	60/61	0.21 ± 0.05	6.34	0.11
Carbon Tetrachloride	0.000006	0.1	61/61	0.62 ± 0.02	3.70	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	58/61	0.20 ± 0.03	2.24	<0.01
1,2-Dichloroethane	0.000026	2.4	38/61	0.07 ± 0.01	1.73	<0.01
Ethylbenzene	0.0000025	1	61/61	0.67 ± 0.11	1.66	<0.01
Formaldehyde	0.000013	0.0098	60/60	3.89 ± 0.22	50.62	0.40
Arsenic (PM ₁₀) ^a	0.0043	0.000015	61/61	0.49 ± 0.08	2.09	0.03
Naphthalene ^a	0.000034	0.003	58/58	93.36 ± 18.63	3.17	0.03
South Phoenix, Arizona - SPAZ						
Benzene	0.0000078	0.03	31/31	1.07 ± 0.21	8.36	0.04
1,3-Butadiene	0.00003	0.002	31/31	0.22 ± 0.07	6.69	0.11
Carbon Tetrachloride	0.000006	0.1	31/31	0.61 ± 0.02	3.63	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	30/31	0.22 ± 0.04	2.40	<0.01
1,2-Dichloroethane	0.000026	2.4	19/31	0.06 ± 0.02	1.58	<0.01
Ethylbenzene	0.0000025	1	31/31	0.68 ± 0.15	1.70	<0.01

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for SPAZ from Table 6-6 include the following:

- The pollutants with the highest annual average concentrations for SPAZ are benzene, ethylbenzene, and carbon tetrachloride. Only benzene has an annual average concentration greater than $1 \mu\text{g}/\text{m}^3$.
- Based on the annual averages and cancer UREs, benzene has the highest cancer risk approximation for SPAZ (8.36 in-a-million), followed by 1,3-butadiene (6.69 in-a-million), and carbon tetrachloride (3.63 in-a-million). These cancer risk

approximations are similar to the approximations calculated for these same pollutants for PXSS.

- None of the pollutants of interest for SPAZ have noncancer hazard approximations greater than 1.0, indicating no adverse noncancer health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation for SPAZ is 1,3-butadiene (0.11).

6.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 6-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 6-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 6-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 6-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 6-7. Table 6-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 6.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 6-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Arizona Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Phoenix, Arizona (Maricopa County) – PXSS					
Benzene	1,313.94	Formaldehyde	1.48E-02	Formaldehyde	50.62
Formaldehyde	1,141.02	Benzene	1.02E-02	Benzene	8.23
Ethylbenzene	862.37	1,3-Butadiene	5.42E-03	1,3-Butadiene	6.34
Acetaldehyde	576.27	Naphthalene	3.02E-03	Acetaldehyde	6.12
1,3-Butadiene	180.82	Ethylbenzene	2.16E-03	Carbon Tetrachloride	3.70
Tetrachloroethylene	95.59	POM, Group 2b	1.48E-03	Naphthalene	3.17
Naphthalene	88.77	Acetaldehyde	1.27E-03	<i>p</i> -Dichlorobenzene	2.24
POM, Group 2b	16.83	POM, Group 2d	1.19E-03	Arsenic	2.09
POM, Group 2d	13.53	Arsenic, PM	1.03E-03	1,2-Dichloroethane	1.73
Dichloromethane	12.34	POM, Group 5a	7.15E-04	Ethylbenzene	1.66
South Phoenix, Arizona (Maricopa County) – SPAZ					
Benzene	1,313.94	Formaldehyde	1.48E-02	Benzene	8.36
Formaldehyde	1,141.02	Benzene	1.02E-02	1,3-Butadiene	6.69
Ethylbenzene	862.37	1,3-Butadiene	5.42E-03	Carbon Tetrachloride	3.63
Acetaldehyde	576.27	Naphthalene	3.02E-03	<i>p</i> -Dichlorobenzene	2.40
1,3-Butadiene	180.82	Ethylbenzene	2.16E-03	Ethylbenzene	1.70
Tetrachloroethylene	95.59	POM, Group 2b	1.48E-03	1,2-Dichloroethane	1.58
Naphthalene	88.77	Acetaldehyde	1.27E-03		
POM, Group 2b	16.83	POM, Group 2d	1.19E-03		
POM, Group 2d	13.53	Arsenic, PM	1.03E-03		
Dichloromethane	12.34	POM, Group 5a	7.15E-04		

Table 6-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Arizona Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Phoenix, Arizona (Maricopa County) – PXSS					
Toluene	5,233.19	Acrolein	2,932,324.18	Formaldehyde	0.40
Xylenes	3,296.34	Formaldehyde	116,431.08	Acetaldehyde	0.31
Hexane	2,752.67	1,3-Butadiene	90,410.71	1,3-Butadiene	0.11
Methanol	2,399.14	Acetaldehyde	64,030.43	Benzene	0.04
Benzene	1,313.94	Benzene	43,798.12	Arsenic	0.03
Formaldehyde	1,141.02	Lead, PM	34,426.96	Naphthalene	0.03
Ethylene glycol	880.96	Xylenes	32,963.37	Carbon Tetrachloride	0.01
Ethylbenzene	862.37	Naphthalene	29,589.71	Ethylbenzene	<0.01
Acetaldehyde	576.27	Arsenic, PM	16,021.47	<i>p</i> -Dichlorobenzene	<0.01
Methyl isobutyl ketone	326.41	Propionaldehyde	10,771.78	1,2-Dichloroethane	<0.01
South Phoenix, Arizona (Maricopa County) – SPAZ					
Toluene	5,233.19	Acrolein	2,932,324.18	1,3-Butadiene	0.11
Xylenes	3,296.34	Formaldehyde	116,431.08	Benzene	0.04
Hexane	2,752.67	1,3-Butadiene	90,410.71	Carbon Tetrachloride	0.01
Methanol	2,399.14	Acetaldehyde	64,030.43	Ethylbenzene	<0.01
Benzene	1,313.94	Benzene	43,798.12	<i>p</i> -Dichlorobenzene	<0.01
Formaldehyde	1,141.02	Lead, PM	34,426.96	1,2-Dichloroethane	<0.01
Ethylene glycol	880.96	Xylenes	32,963.37		
Ethylbenzene	862.37	Naphthalene	29,589.71		
Acetaldehyde	576.27	Arsenic, PM	16,021.47		
Methyl isobutyl ketone	326.41	Propionaldehyde	10,771.78		

Observations from Table 6-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Maricopa County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, benzene, and 1,3-butadiene.
- Eight of the highest emitted pollutants in Maricopa County also have the highest toxicity-weighted emissions.
- Formaldehyde has the highest cancer risk approximation for PXSS; carbonyl compounds were not sampled for at SPAZ, thus, a cancer risk approximation is not available for this pollutant for SPAZ. Formaldehyde has the second highest emissions and the highest toxicity-weighted emissions for Maricopa County. Acetaldehyde, which has the fourth highest cancer risk approximation for PXSS, also appears on both emissions-based list for Maricopa County.
- Among the VOCs, benzene, 1,3-butadiene, and carbon tetrachloride have highest cancer risk approximations for PXSS and SPAZ. The cancer risk approximations for these pollutants are similar between the two sites. While benzene and 1,3-butadiene both appear among the pollutants with the highest emissions and highest toxicity-weighted emissions for Maricopa County, carbon tetrachloride does not appear on either list.
- Naphthalene is among the highest emitted pollutants (seventh), has one of the highest toxicity-weighted emissions (fourth), and has one of the highest cancer risk approximations for PXSS (sixth). POM, Group 2b is the eighth highest emitted “pollutant” in Maricopa County and ranks sixth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at PXSS including acenaphthene, benzo(e)pyrene, fluoranthene, and perylene. Similarly, POM, Group 2d is the ninth highest emitted “pollutant” and ranks eighth for toxicity-weighted emissions. POM, Group 2d includes several PAHs sampled for at PXSS including anthracene, phenanthrene, and pyrene. None of the PAHs included in POM, Groups 2b or 2d were identified as pollutants of interest for PXSS (or failed any screens). POM, Group 5a ranks tenth for toxicity-weighted emissions for Maricopa County. This POM group includes benzo(a)pyrene, which failed three screens for PXSS but was not identified as a pollutant of interest for this site.
- Arsenic has the eighth highest cancer risk approximation among the pollutants of interest for PXSS. This pollutant ranks ninth for its toxicity-weighted emissions but does not appear among the highest emitted pollutants in Maricopa County (it ranks 20th).

Observations from Table 6-8 include the following:

- Toluene, xylenes, and hexane are the highest emitted pollutants with noncancer RfCs in Maricopa County.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and 1,3-butadiene.
- Four of the highest emitted pollutants also have the highest toxicity-weighted emissions for Maricopa County.
- Acrolein has the highest toxicity-weighted emissions for Maricopa County. Although acrolein was sampled for at both sites, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. The emissions for acrolein rank 16th.
- Formaldehyde and acetaldehyde have the highest noncancer hazard approximations for PXSS (although considerably less than an HQ of 1.0), both of which appear among those with the highest emissions and toxicity-weighted emissions for Maricopa County.
- 1,3-Butadiene and benzene have the highest noncancer hazard approximations among the VOCs for both PXSS and SPAZ and are similar in magnitude between the two sites. Benzene ranks fifth for both its emissions and its toxicity-weighted emissions. 1,3-Butadiene has the third highest toxicity-weighted emissions for Maricopa County but is not one of the highest emitted pollutants in Maricopa County (with a noncancer RfC), as it ranks 11th.

6.6 Summary of the 2013 Monitoring Data for PXSS and SPAZ

Results from several of the data treatments described in this section include the following:

- ❖ *Eighteen pollutants failed screens for PXSS; six pollutants failed screens for SPAZ.*
- ❖ *Of the site-specific pollutants of interest for PXSS, formaldehyde had the highest annual average concentration. For SPAZ, benzene had the highest annual average concentration among this site's pollutants of interest.*
- ❖ *Concentrations of several VOCs, particularly benzene and 1,3-butadiene, tended to be higher during the colder months of the year. This was also reflected in the concentration data from previous years of sampling.*
- ❖ *SPAZ and PXSS have the highest and second highest annual average concentrations of p-dichlorobenzene among NMP sites sampling VOCs. These sites also rank third and fourth highest for ethylbenzene.*
- ❖ *Concentrations of benzene appear to be decreasing at the Arizona sites. The detection rate of 1,2-dichloroethane increased significantly during the later years of sampling. Arsenic concentrations have decreased at PXSS the last few years.*

- ❖ *Formaldehyde has the highest cancer risk approximation of the pollutants of interest for PXSS; benzene has the highest cancer risk approximation of the pollutants of interest for SPAZ. None of the pollutants of interest for either site have noncancer hazard approximations greater than an HQ of 1.0.*

7.0 Sites in California

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at three NATTS sites and one CSATAM site in California, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

7.1 Site Characterization

This section characterizes the California monitoring sites by providing geographical and physical information about the locations of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

Three monitoring sites are located in southern California cities: Los Angeles, Long Beach, and Rubidoux. A fourth monitoring site is located in San Jose, which is in northern California. Figures 7-1 and 7-2 are the composite satellite images retrieved from ArcGIS Explorer showing the Los Angeles and Long Beach monitoring sites and their immediate surroundings, respectively. Figure 7-3 identifies nearby point source emissions locations by source category for each site, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 7-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside each 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Figures 7-4 through 7-7 are the composite satellite images and emissions maps for the Rubidoux and San Jose monitoring sites. Table 7-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 7-1. Los Angeles, California (CELA) Monitoring Site



Figure 7-2. Long Beach, California (LBHCA) Monitoring Site

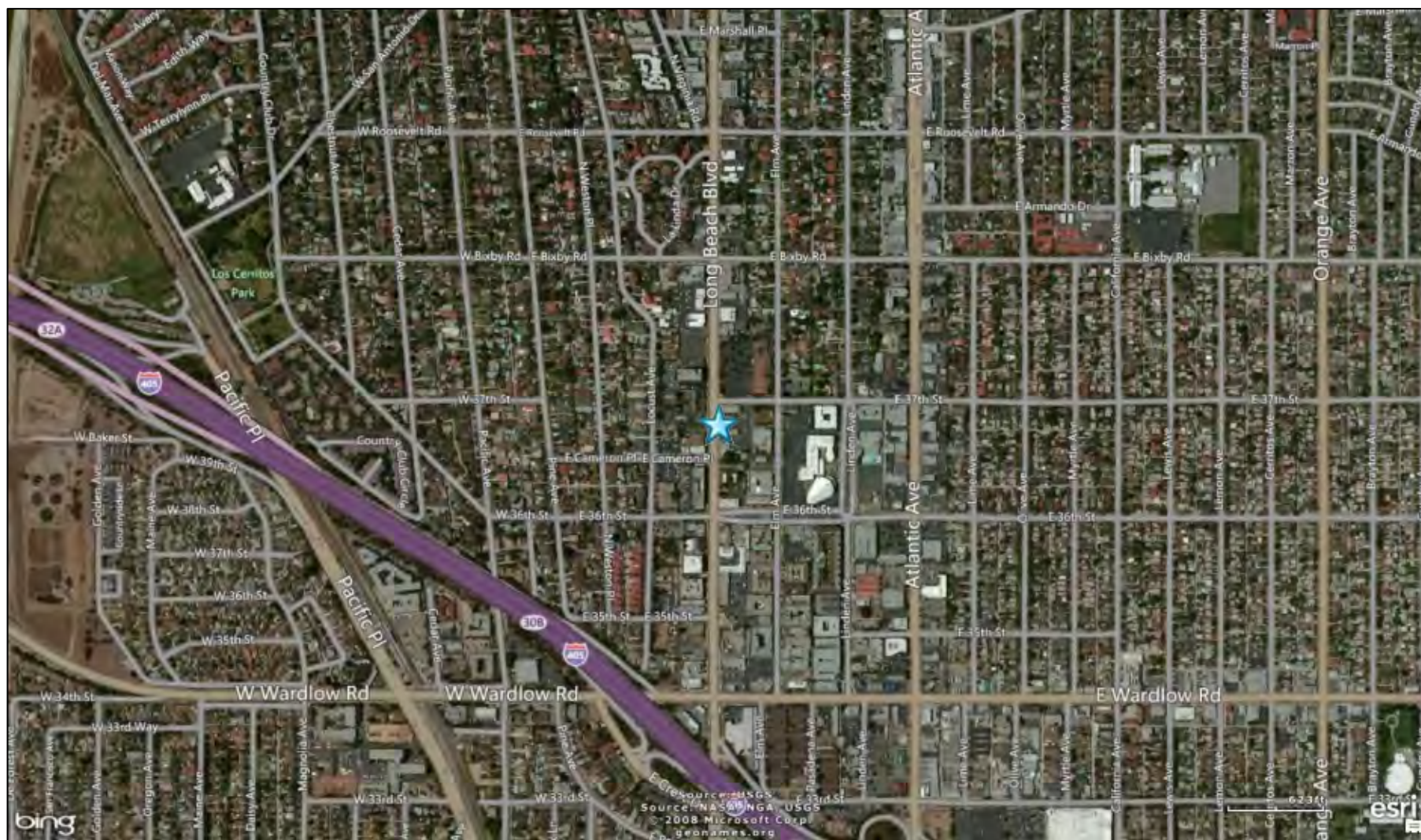
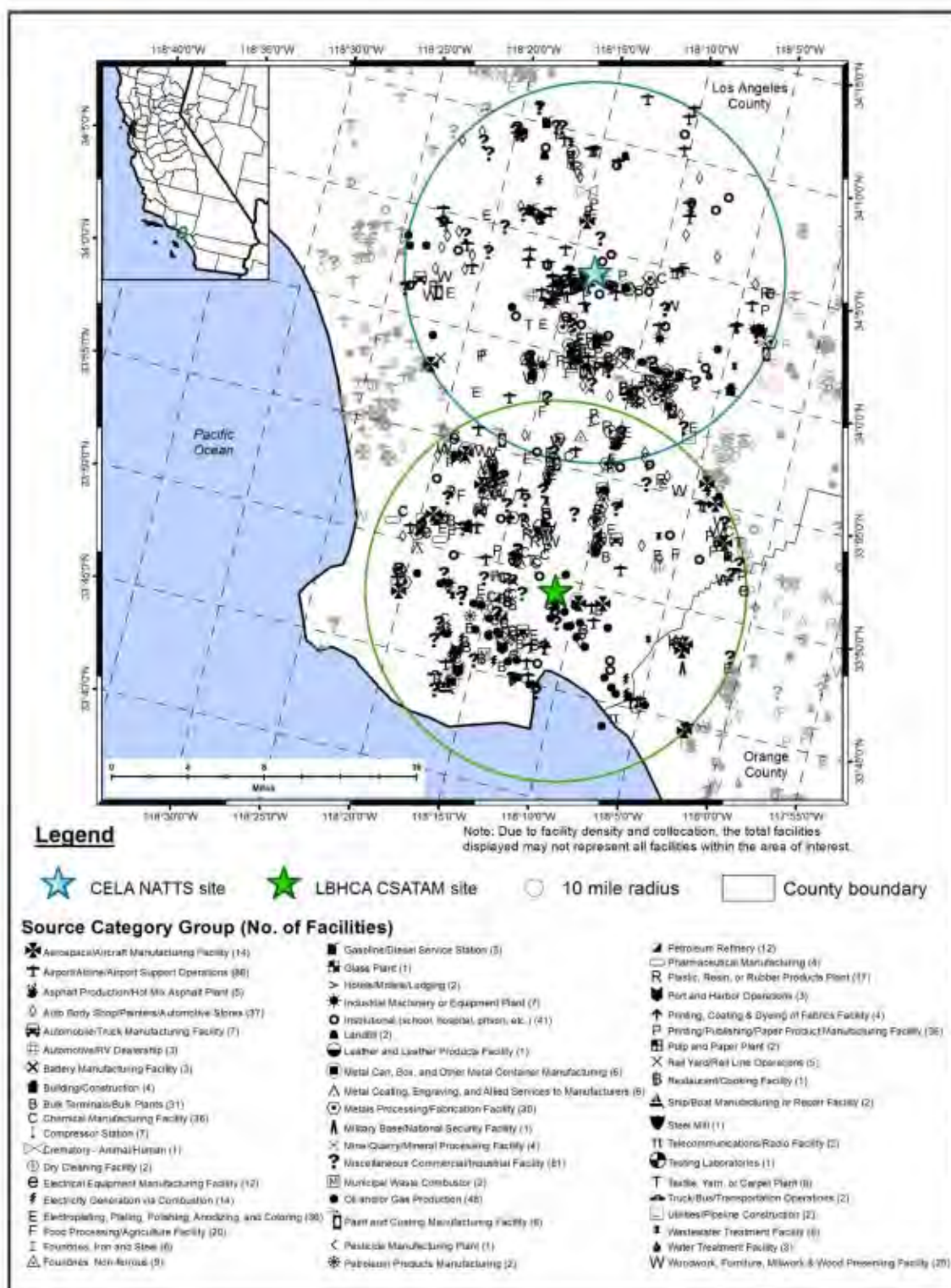


Figure 7-3. NEI Point Sources Located Within 10 Miles of CELA and LBHCA



7-5

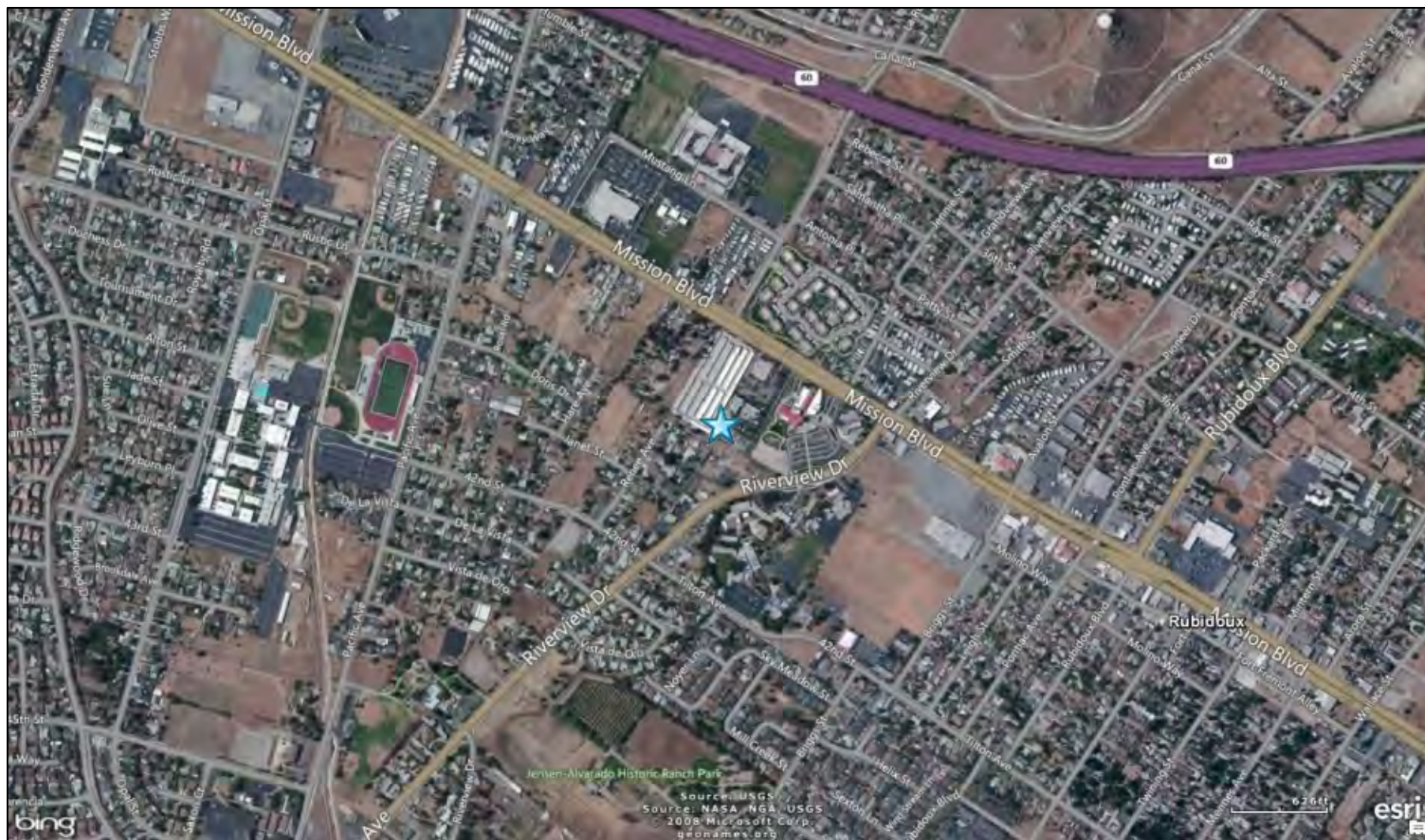


Figure 7-5. NEI Point Sources Located Within 10 Miles of RUCA

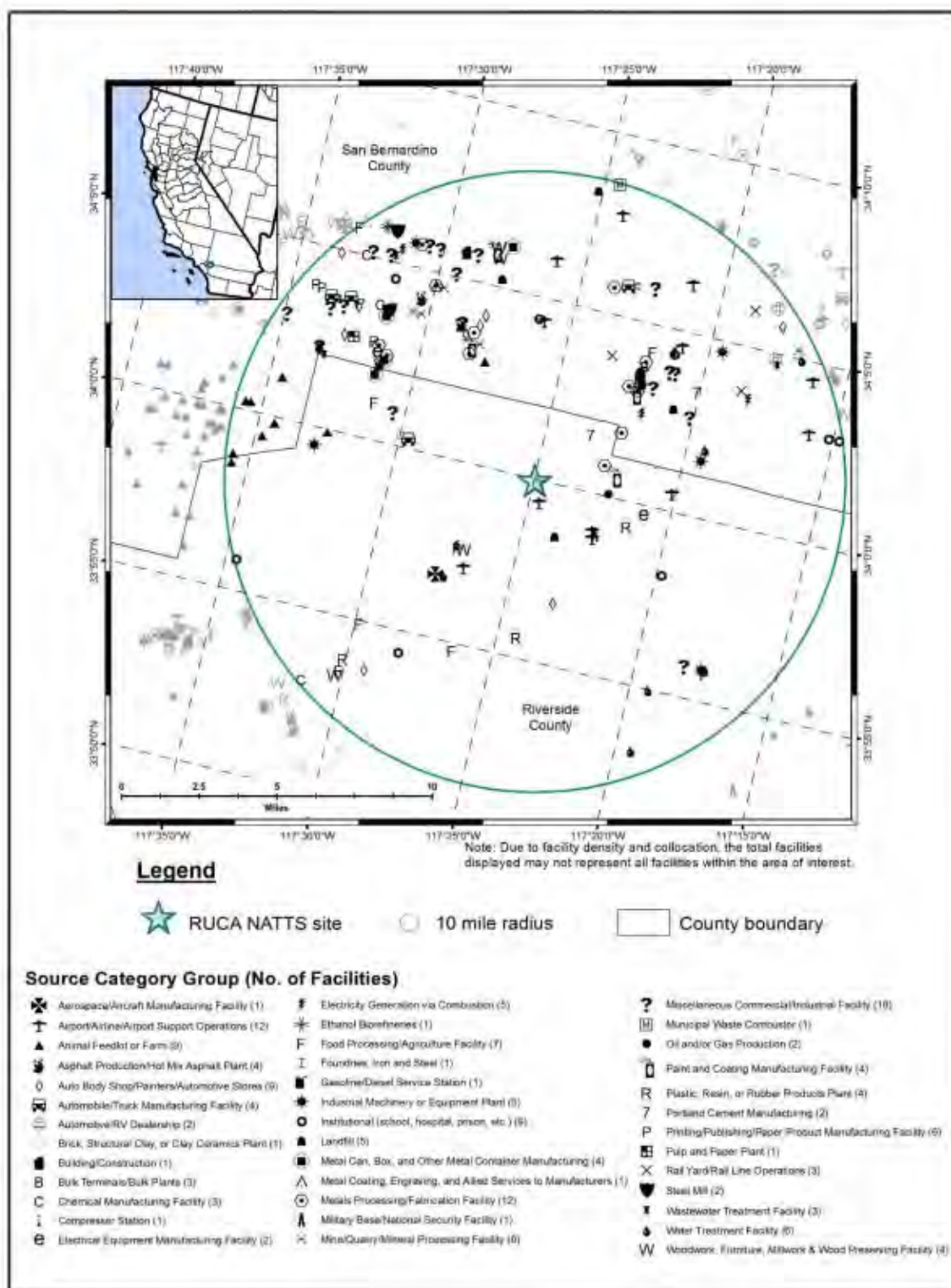


Figure 7-6. San Jose, California (SJJCA) Monitoring Site

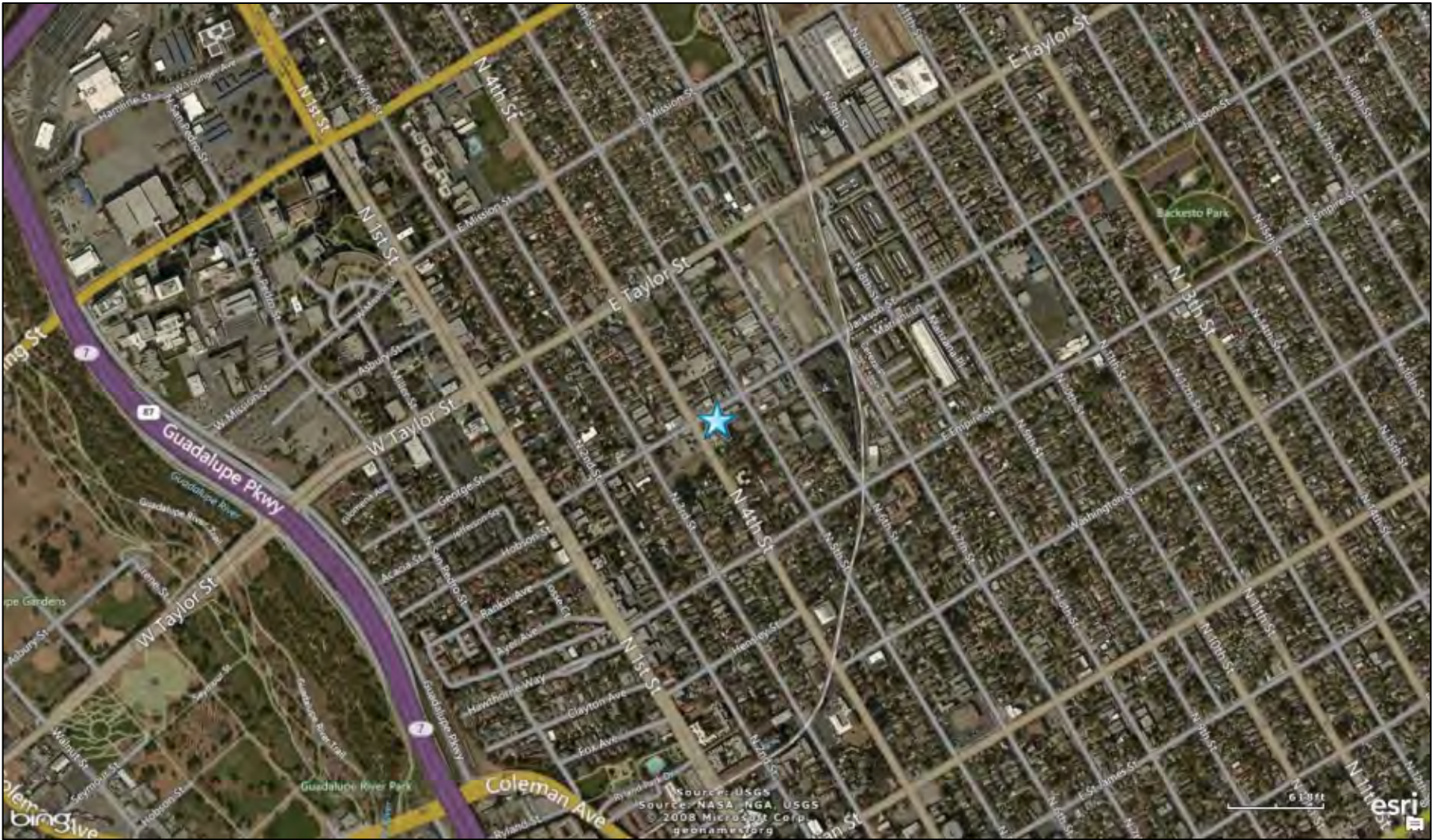


Figure 7-7. NEI Point Sources Located Within 10 Miles of SJJCA

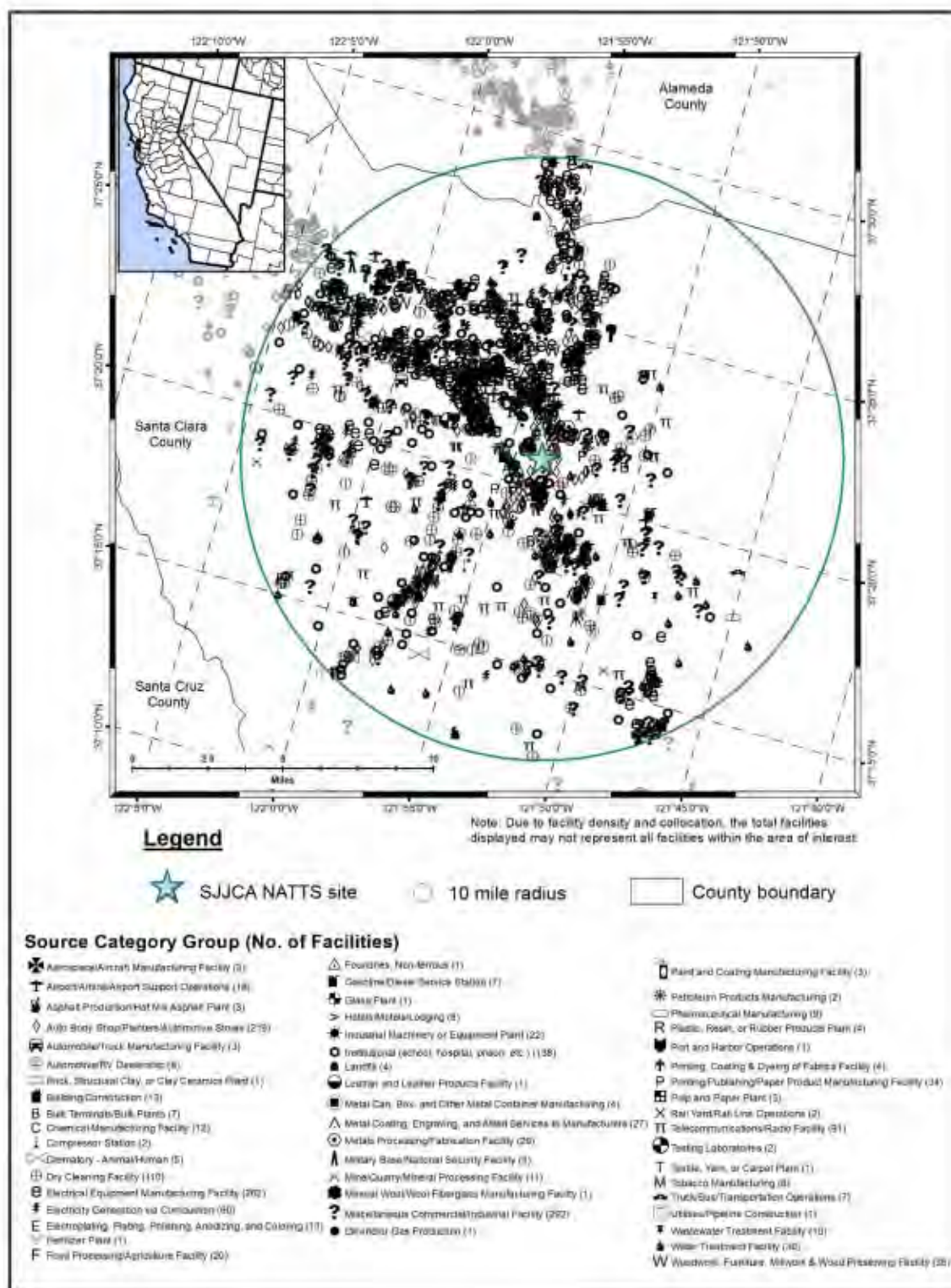


Table 7-1. Geographical Information for the California Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>CELA</i>	06-037-1103	Los Angeles	Los Angeles	Los Angeles-Long Beach-Anaheim, CA	34.06659, -118.22688	Residential	Urban/City Center	TSP, TSP Speciation, CO, SO ₂ , NO, NO ₂ , NO _x , NO _y , PAMS, Carbonyl compounds, VOCs, SNMOC, O ₃ , Meteorological parameters, PM ₁₀ , PM ₁₀ Speciation, PM Coarse, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation, Methane.
LBHCA	06-037-4002	Long Beach	Los Angeles	Los Angeles-Long Beach-Anaheim, CA	33.82376, -118.18921	Residential	Suburban	TSP, TSP Speciation, CO, SO ₂ , NO, NO ₂ , NO _x , VOCs, Carbonyl compounds, O ₃ , Meteorological parameters, PM ₁₀ , PM ₁₀ Speciation, PM _{2.5} , PM _{2.5} Speciation
<i>RUCA</i>	06-065-8001	Rubidoux	Riverside	Riverside-San Bernardino-Ontario, CA	33.99958, -117.41601	Residential	Suburban	Haze, TSP, TSP Speciation, CO, SO ₂ , NO, NO ₂ , NO _x , NO _y , PAMS, VOCs, SNMOC, Carbonyl compounds, O ₃ , Meteorological parameters, PM ₁₀ , PM ₁₀ Speciation, PM Coarse, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
<i>SJJCA</i>	06-085-0005	San Jose	Santa Clara	San Jose-Sunnyvale-Santa Clara, CA	37.348497, -121.894898	Commercial	Urban/City Center	TSP Speciation, CO, SO ₂ , NO, NO ₂ , NO _x , NO _y , VOCs, Carbonyl compounds, O ₃ , Meteorological parameters, PM ₁₀ , PM Coarse, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

CELA is located on the rooftop of a two-story building northeast of downtown Los Angeles, just southeast of Dodgers' Stadium and Los Angeles State Historic Park, which are prominent features in Figure 7-1. CELA is surrounded by major freeways, including I-5 and Route 110. Highway 101 is located farther south. Although the area is classified as residential, a freight yard is located to the south of the site. The Los Angeles River runs north-south just east of the site. This monitoring site was originally set up as an emergency response monitoring site.

The LBHCA monitoring site is located on the property of a church in Long Beach. The surrounding area is considered residential and suburban, although commercial areas are also located nearby and along Long Beach Boulevard, as shown in Figure 7-2. Interstate-405 is located approximately one-fifth of a mile from LBHCA and intersects with I-710 just 1 mile west of the site. This monitoring site is located approximately 4 miles north of the shores of Long Beach and the Port of Long Beach, the second-busiest port in the U.S. (POLB, 2015).

LBHCA is nearly 17 miles south of CELA. Figure 7-3 shows that these sites are situated among a high density of point sources. The source category with the greatest number of emissions sources near these monitoring sites is the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. Other source categories with a large number of emissions sources within 10 miles of CELA and LBHCA are oil and gas production; institutions such as school, hospitals, and/or prisons; auto body shops, painters, and automotive stores; printing, publishing, and paper product manufacturing; electroplating, plating, polishing, anodizing, and coloring; and chemical manufacturing. A number of emissions sources are located immediately around CELA, with a high density cluster of emissions sources located just to the west and southwest of the site. The sources closest to CELA are a mineral processing facility, a carpet plant, a facility involved in oil/gas production, and a heliport at a detention center. Several emissions sources are located directly south of LBHCA, including several involved in oil and gas production.

RUCA is located just north of Riverside, in a residential area in the suburban town of Rubidoux. Figure 7-4 shows that RUCA is adjacent to a power substation west of a storage facility near the intersection of Mission Boulevard and Riverview Drive. Residential areas surround RUCA, including three schools: a middle school north of Mission Boulevard, an

elementary school south of Riverview Drive, and a high school to the west of Pacific Avenue, the football and baseball fields of which are prominent features in Figure 7-4. Highway 60 runs east-west to the north of the site. Flabob Airport is located approximately three-quarters of a mile to the southeast of the site. RUCA is located approximately 44 miles west-southwest of CELA and 45 miles northwest of LBHCA. Figure 7-5 shows that fewer emissions sources surround RUCA than CELA and LBHCA. Most of the emissions sources are located to the northeast and northwest of the site in San Bernardino County. The point source located closest to RUCA is Flabob Airport. Although the emissions source categories are varied, the emissions source categories with the greatest number of sources within 10 miles of RUCA include airport operations; metals processing and fabrication; auto body shops, painters, and automotive stores; animal feedlots or farms; and institutions such as school, hospitals, and/or prisons.

SJJCA is located in central San Jose. Figure 7-6 shows that SJJCA is located in a commercial area surrounded by residential areas. A railroad is shown east of the monitoring site, running north-south in Figure 7-6. Guadalupe Parkway (Route 87) intersects with I-880 approximately 1 mile northwest of the monitoring site. San Jose International Airport is just on the other side of this intersection. The Guadalupe River runs along the eastern boundary of the airport and runs parallel to the Guadalupe Parkway, as does the Guadalupe River Park and Gardens, a park and trail system which can be seen on the bottom left of Figure 7-6. Figure 7-7 shows that the density of point sources is significantly higher near SJJCA than the other California monitoring sites. The emissions source categories with the greatest number of sources surrounding SJJCA are electrical equipment manufacturing; auto body, paint, and automotive shops; institutions such as school, hospitals, and/or prisons; dry cleaning; and telecommunications. Sources closest to SJJCA include a food processing facility and several auto body shops.

Table 7-2 presents additional site-characterizing information, including indicators of mobile source activity, for the California monitoring sites. Table 7-2 includes both county-level population and vehicle registration information. Table 7-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 7-2 presents the county-level daily VMT for Los Angeles, Riverside, and Santa Clara Counties.

Table 7-2. Population, Motor Vehicle, and Traffic Information for the California Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
CELA	Los Angeles	10,017,068	7,609,517	231,000	I-5 between Main St. and Broadway (exit 136 and 137)	214,482,440
LBHCA				285,000	I-405 between Wardlow Rd and I-710 (exit 30 and 32)	
RUCA	Riverside	2,292,507	1,788,322	150,000	60 (Mission Blvd) between Rubidoux Blvd and Valley Way	55,336,730
SJJCA	Santa Clara	1,862,041	1,575,973	115,000	87 (Guadalupe Pkwy) between Julian St and W Taylor St	41,478,310

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflects 2013 data (CA DMV, 2013)

³AADT reflects 2013 data (CA DOT, 2013a)

⁴County-level VMT reflects 2012 data (CA DOT, 2013b)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 7-2 include the following:

- Los Angeles County (CELA and LBHCA) has the highest county-level population and vehicle registration compared to all counties with NMP sites. The county-level population for Los Angeles County is twice the population for the next highest county (Cook County, IL) and the county-level vehicle registration for Los Angeles County is twice the registration for the next highest county (Maricopa County, AZ).
- Riverside and Santa Clara Counties are also in the top 10 for county-level population and vehicle registration among counties with NMP sites.
- LBHCA experiences the highest annual average daily traffic among NMP sites, with CELA's traffic ranking third. These two sites, in addition to ELNJ, are the only ones with traffic volumes greater than 200,000. These two sites are located relatively close to major freeways in the Los Angeles metro area. The traffic volume for RUCA also ranks among the top 10. The traffic volume for SJJCA ranks 12th compared to other NMP sites.
- Los Angeles County's daily VMT is the highest among all counties with NMP sites, and is nearly double the next highest county-level VMT (Maricopa County, AZ). The VMT for Riverside and Santa Clara Counties are also in the top 10 for VMT among counties with NMP sites, ranking fifth and seventh, respectively.

7.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in California on sample days, as well as over the course of the year.

7.2.1 Climate Summary

The climate of Los Angeles and the surrounding areas is generally mild. While the proximity to the Pacific Ocean acts as a moderating influence on the Los Angeles area, the elevation changes between the mountains and valleys allow the distance from the ocean to create substantial differences in temperature, rainfall, and wind over a relatively short distance. Precipitation falls primarily in winter months, while summers tend to be dry. Westerly winds are prevalent for much of the year. Stagnant wind conditions in the summer can result in air pollution episodes, while breezy Santa Ana winds can create hot, dusty conditions. Fog and cloudy conditions are more prevalent near the coast than farther inland (Wood, 2004; WRCC, 2014).

San Jose is located to the southeast of San Francisco, near the base of the San Francisco Bay. The city is situated in the Santa Clara Valley, between the Santa Cruz Mountains to the south and west and the Diablo Range to the east. San Jose experiences a Mediterranean climate, with distinct wet-dry seasons. The period from November through March represents the wet season, with cool but mild conditions prevailing. Little rainfall occurs the rest of the year and conditions tend to be warm and sunny. San Jose is not outside the marine influences of the cold ocean currents typically affecting the San Francisco area (Wood, 2004; NOAA, 1999).

7.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the California monitoring sites (NCDC, 2013), as described in Section 3.4.2. The weather station nearest CELA is located at Downtown Los Angeles/USC Campus; the weather station nearest LBHCA is located at Long Beach/Daugherty Field Airport; the nearest weather station to RUCA is located at Riverside Municipal Airport; and the nearest station to SJCA is located at San Jose International Airport (WBANs 93134, 23129, 03171, and 23293, respectively). Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 7-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 7-3. Average Meteorological Conditions near the California Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Los Angeles, California - CELA									
Downtown L.A./USC Campus Airport 93134 (34.02, -118.29)	4.7 miles	Sample Days (62)	74.9 ± 2.0	64.3 ± 1.7	48.3 ± 3.0	56.0 ± 1.9	60.6 ± 3.5	1015.2 ± 1.1	1.2 ± 0.2
	231° (SW)	2013	74.3 ± 0.8	64.0 ± 0.7	48.0 ± 1.2	55.8 ± 0.7	61.1 ± 1.6	1014.9 ± 0.4	1.1 ± 0.1
Long Beach, California - LBHCA									
Long Beach/Daugherty Field Airport 23129 (33.82, -118.15)	2.6 miles	Sample Days (35)	71.8 ± 2.4	62.7 ± 2.2	48.5 ± 3.5	55.3 ± 2.4	63.5 ± 4.2	1015.5 ± 1.3	4.5 ± 0.6
	109° (ESE)	2013	73.9 ± 0.9	64.0 ± 0.7	48.7 ± 1.1	56.0 ± 0.7	62.1 ± 1.4	1015.1 ± 0.4	4.0 ± 0.2
Rubidoux, California - RUCA									
Riverside Municipal Airport 03171 (33.95, -117.44)	3.5 miles	Sample Days (61)	80.3 ± 2.9	66.0 ± 2.5	43.7 ± 3.5	54.6 ± 2.1	51.2 ± 4.1	1014.2 ± 1.1	3.5 ± 0.3
	202° (SSW)	2013	79.7 ± 1.3	66.0 ± 1.0	43.2 ± 1.4	54.5 ± 0.9	51.1 ± 1.8	1013.9 ± 0.4	3.7 ± 0.1
San Jose, California - SJJCA									
San Jose Intl. Airport 23293 (37.36, -121.92)	1.8 miles	Sample Days (66)	71.2 ± 2.3	59.1 ± 2.0	45.1 ± 2.0	51.9 ± 1.8	63.3 ± 2.2	1017.3 ± 1.2	4.9 ± 0.6
	295° (WNW)	2013	70.3 ± 1.0	58.8 ± 0.9	45.6 ± 0.9	52.0 ± 0.7	65.4 ± 1.1	1017.0 ± 0.5	5.0 ± 0.2

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 7-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 7-3 is the 95 percent confidence interval for each parameter. As shown in Table 7-3, average meteorological conditions on sample days near CELA, RUCA, and SJCA were representative of average weather conditions experienced throughout the year. The largest difference in the table for these sites is for average relative humidity for SJCA, but is still less than 2 percent different.

The differences between the average meteorological conditions for 2013 and those experienced on sample days near LBHCA are greater than the other sites, particularly for temperature. A 1-year sampling effort at LBHCA was completed at the end of July 2013; therefore, the sample day averages for this site include only data for the first half of 2013. However, the differences between the full-year averages and the sample day averages are still relatively small, with the largest difference calculated for average maximum temperature.

Table 7-3 shows that wind speeds near the southern California sites tend to be rather light, particularly for CELA, which has the lowest average scalar wind speed in 2013 among all NMP sites. As expected, conditions in 2013 were cooler near SJCA than near the other sites. For the southern California sites, average temperatures in 2013 tended to be slightly higher for RUCA, which is farther inland than the other two sites.

7.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations at the Downtown Los Angeles/USC Campus (for CELA), Long Beach/Daugherty Field Airport (for LBHCA), Riverside Municipal Airport (for RUCA), and San Jose International Airport (for SJCA) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 7-8 presents a map showing the distance between the weather station and CELA, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 7-8 also presents three different wind roses for the

CELA monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 7-9 through 7-11 present the distance maps and wind roses for LBHCA, RUCA, and SJCA, respectively.

Observations from Figure 7-8 for CELA include the following:

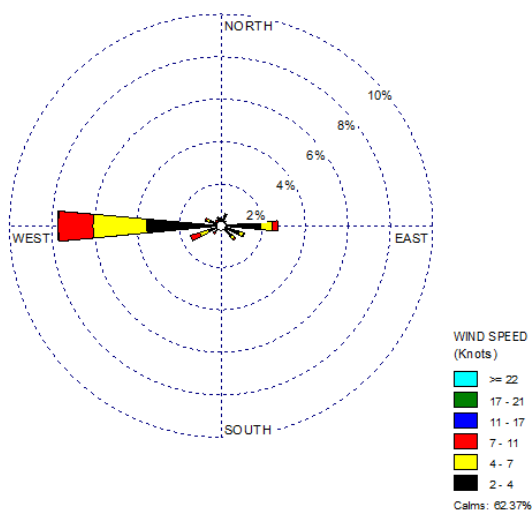
- The weather station at the Downtown Los Angeles/USC Campus is located 4.7 miles southwest of CELA.
- Historically, winds were generally light near this site, with calm winds (those less than or equal to 2 knots) observed for more than 60 percent of the wind observations. For wind speeds greater than 2 knots, westerly winds were most common, followed by easterly and west-southwesterly winds. Wind speeds greater than 17 knots were not measured at this weather station during this time frame.
- The 2013 full-year and sample day wind roses are similar to the historical wind rose in that calm winds make up the majority of the observations and that westerly winds were prominent. However, a higher percentage of calm winds were measured in 2013 while west-southwesterly winds were rarely observed. Yet, the wind patterns shown on the full-year and sample day wind roses generally resemble the historical wind patterns, indicating that conditions in 2013 and on sample days were representative of those experienced historically.

Figure 7-8. Wind Roses for the Downtown Los Angeles/USC Campus Weather Station near CELA

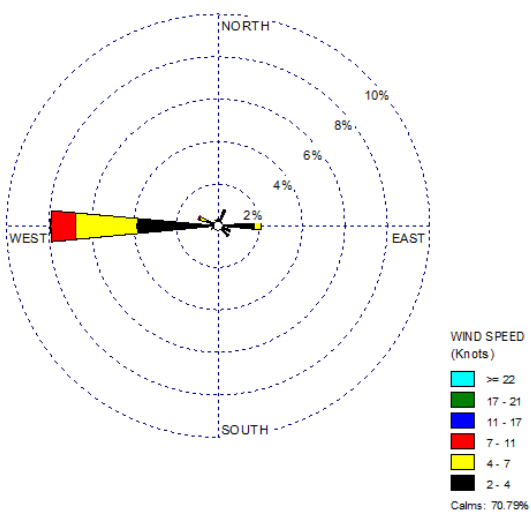
Location of CELA and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

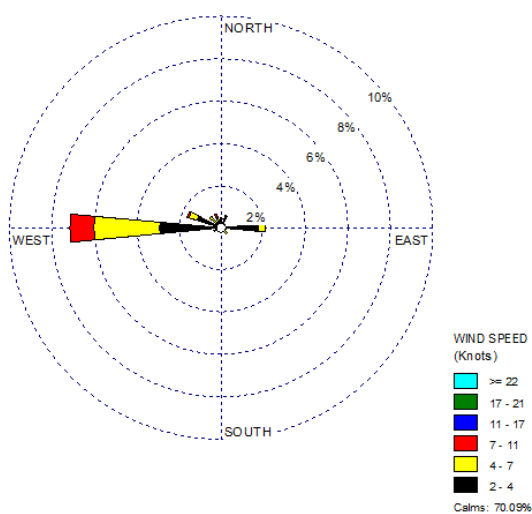
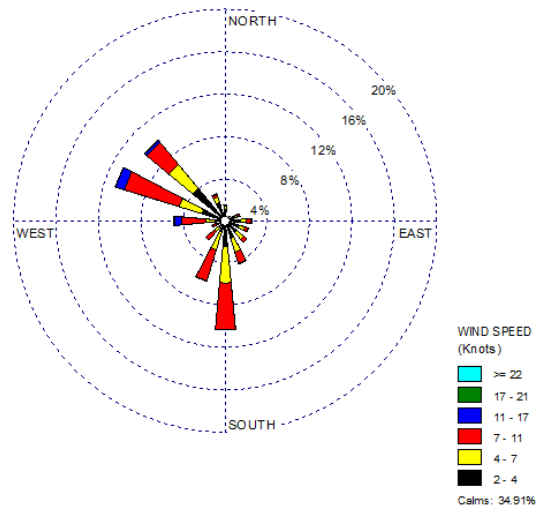


Figure 7-9. Wind Roses for the Long Beach/Daugherty Field Airport Weather Station near LBHCA

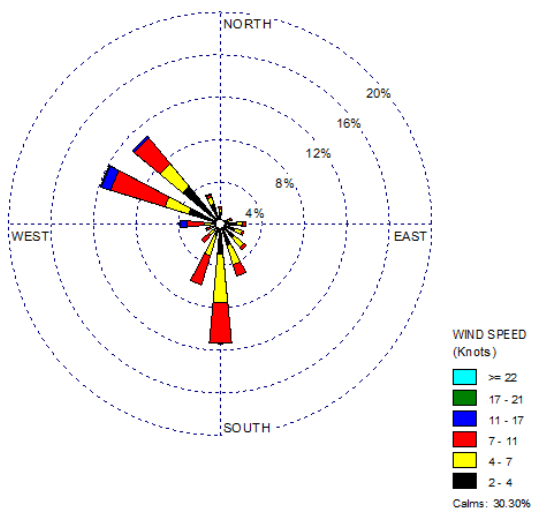
Location of LBHCA and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

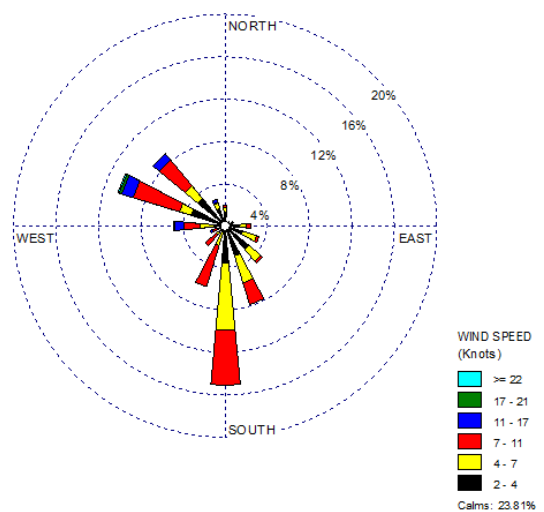
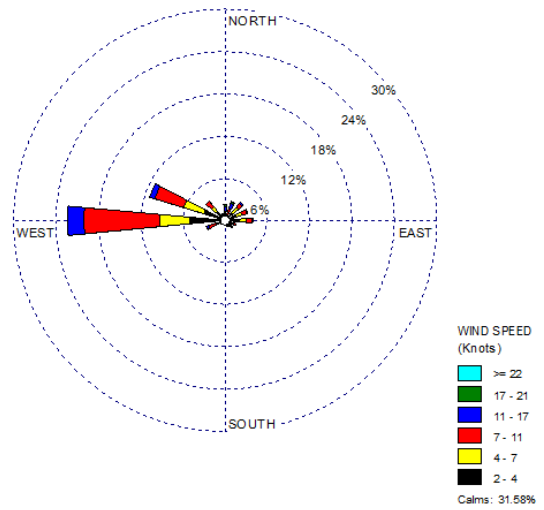


Figure 7-10. Wind Roses for the Riverside Municipal Airport Weather Station near RUCA

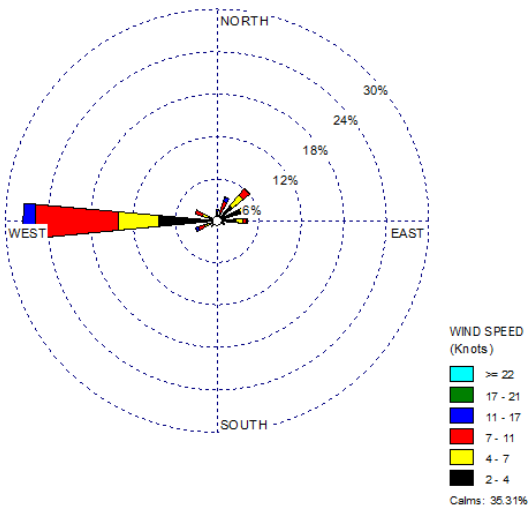
Locations of RUCA and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

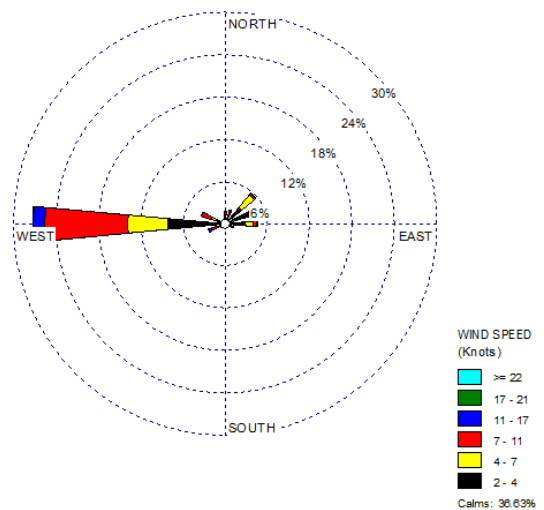
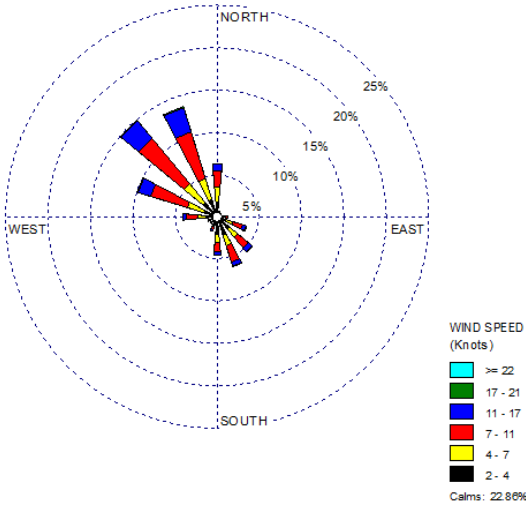


Figure 7-11. Wind Roses for the San Jose International Airport Weather Station near SJJCA

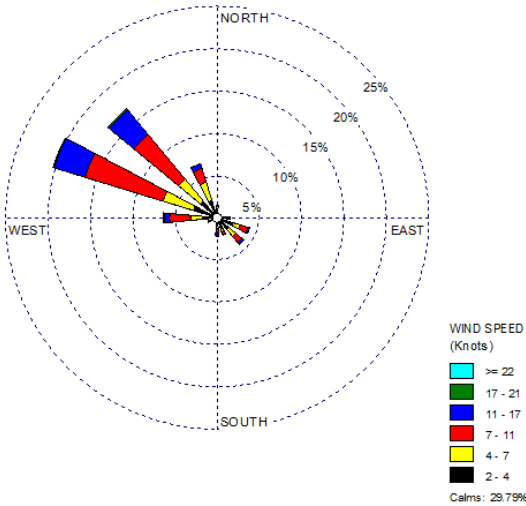
Location of SJJCA and Weather Station



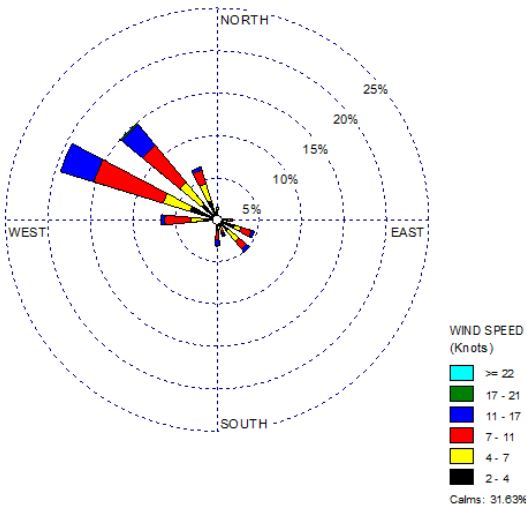
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 7-9 for LBHCA include the following:

- The weather station at the Long Beach/Daugherty Field Airport is located 2.6 miles east-southeast of LBHCA.
- The historical wind rose shows that calm winds were observed for more than one-third of the observations near LBHCA. Winds from the west-northwest and northwest together account for approximately 20 percent of the wind observations while winds from the south account for another 10 percent of observations. Winds from the northeast quadrant were generally not observed near this site.
- The wind patterns on the 2013 full-year wind rose are very similar to the historical wind patterns, indicating that conditions in 2013 were representative of those experienced historically.
- The sample day wind rose has a lower percentage of calm winds than the historical and full-year wind roses. The sample day wind rose also has fewer west-northwesterly and northwesterly wind observations and a higher percentage of winds from the south-southeast and south. Recall however, that sampling at LBHCA was completed in July, and thus does not include wind observations from the second half of 2013. The wind patterns on the sample day wind rose may be indicative of a seasonal wind pattern.

Observations from Figure 7-10 for RUCA include the following:

- The weather station at the Riverside Municipal Airport is located 3.5 miles south-southwest of RUCA. The Santa Ana River and Wildlife Area lies between the airport and the monitoring site.
- Although calm winds were observed for approximately 32 percent of the wind observations near RUCA, westerly and west-northwesterly winds were also frequently observed, accounting for approximately 21 percent and 12 percent of wind observations, respectively, based on the historical wind rose.
- The full-year wind rose shows that west-northwesterly winds were observed less frequently in 2013, as westerly winds account for more than 25 percent of observations in 2013. As similar observation was noted in the 2011 and 2012 NMP reports. Although still relatively low, the percentage of northeasterly winds shown on the full-year wind rose is roughly double what is shown on the historical wind rose.
- The wind patterns shown on the sample day wind rose resemble the wind patterns shown on the full-year wind rose, indicating that conditions on sample days in 2013 were representative of those experienced over the entire year.

Observations from Figure 7-11 for SJJCA include the following:

- The weather station at the San Jose International Airport is located 1.8 miles west-northwest of SJJCA. Even though I-880, the Guadalupe Parkway, and the Guadalupe

River separate the airport and the monitoring site, this is one of the shortest distances between a weather station and an NMP site.

- Between 2003 and 2012, approximately 40 percent of winds near SJJCA were from the west-northwest to north. Another 17 percent of winds were from the southeast to south. Winds from the northeastern and southwestern quadrants were rarely observed. Approximately one-fifth of the winds were calm.
- The wind patterns on the full-year and sample day wind roses exhibit a shift in primary wind direction, from west-northwest to north on the historical wind rose to west to north-northwest on the 2013 wind roses. This shift is also shown in the secondary wind directions, from southeast to south on the historical to east-southeast to southeast on the 2013 wind rose. This shift was also shown on the 2009 through 2012 wind roses in the 2008-2009, 2010, 2011, and 2012 NMP reports.
- The wind patterns shown on the sample day wind rose generally resemble the wind patterns shown on the full-year wind rose, indicating that conditions on sample days were representative of those experienced over the entire year.

7.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each California monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 7-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 7-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. PAHs were sampled for at all four California sites; in addition, metals (PM₁₀) were also sampled for at SJJCA.

Table 7-4. Risk-Based Screening Results for the California Monitoring Sites

Pollutant	Screening Value ($\mu\text{g}/\text{m}^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Los Angeles, California - CELA						
Naphthalene	0.029	56	58	96.55	94.92	94.92
Acenaphthene	0.011	1	58	1.72	1.69	96.61
Benzo(a)pyrene	0.00057	1	32	3.13	1.69	98.31
Fluorene	0.011	1	57	1.75	1.69	100.00
Total		59	205	28.78		
Long Beach, California - LBHCA						
Naphthalene	0.029	19	29	65.52	100.00	100.00
Total		19	29	65.52		
Rubidoux, California - RUCA						
Naphthalene	0.029	53	58	91.38	98.15	98.15
Benzo(a)pyrene	0.00057	1	35	2.86	1.85	100.00
Total		54	93	58.06		
San Jose, California - SJJCA						
Naphthalene	0.029	48	59	81.36	46.60	46.60
Arsenic (PM_{10})	0.00023	41	56	73.21	39.81	86.41
Nickel (PM_{10})	0.0021	11	60	18.33	10.68	97.09
Benzo(a)pyrene	0.00057	1	25	4.00	0.97	98.06
Cadmium (PM_{10})	0.00056	1	60	1.67	0.97	99.03
Lead (PM_{10})	0.015	1	60	1.67	0.97	100.00
Total		103	320	32.19		

Observations from Table 7-4 include the following:

- Naphthalene failed the majority of screens for all three California monitoring sites where only PAHs were sampled. Naphthalene's site-specific contribution to the total failed screens for these sites ranges from 95 percent (CELA) to 100 percent (LBHCA).
- Naphthalene was detected in all 58 valid PAH samples collected at CELA and failed screens for 56 of these. Acenaphthene, benzo(a)pyrene, and fluorene also failed a single screen each for CELA; because all three of these pollutants failed the same number of screens, all three, in addition to naphthalene, were identified as pollutants of interest for CELA.
- Naphthalene was the only PAH to fail screens for LBHCA; thus naphthalene is the only pollutant of interest for this site. Note that PAH sampling was discontinued in July 2013.

- Naphthalene was detected in all 58 valid PAH samples collected at RUCA and failed screens for 53 of these, accounting for 98 percent of this site's failed screens. Benzo(a)pyrene also failed a single screen for RUCA, but was not identified as a pollutant of interest.
- SJJCA is the only site that sampled metals (PM₁₀) in addition to PAHs. Although naphthalene still accounts for the majority of failed screens for the site, arsenic also contributed to a large number of the total failed screens. Together, these two pollutants account for nearly 86 percent of SJJCA's total failed screens. Nickel accounts for another 11 percent of the total failed screens for this site. Naphthalene, arsenic, and nickel contributed to more than 95 percent of failed screens for SJJCA and were therefore identified as pollutants of interest for this site. Benzo(a)pyrene, cadmium, and lead also failed a single screen each for SJCCA but were not identified as pollutants of interest.

7.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the California monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at the California monitoring sites are provided in Appendices M and N.

7.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each California site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total

number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the California monitoring sites are presented in Table 7-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 7-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the California Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
Los Angeles, California - CELA						
Acenaphthene	58/58	3.95 ± 1.35	3.56 ± 0.78	4.72 ± 1.29	4.71 ± 0.86	4.26 ± 0.54
Benzo(a)pyrene	32/58	0.05 ± 0.04	0.02 ± 0.02	0.07 ± 0.10	0.08 ± 0.04	0.06 ± 0.03
Fluorene	57/58	5.04 ± 1.02	5.46 ± 1.45	6.48 ± 1.41	5.68 ± 0.84	5.67 ± 0.57
Naphthalene	58/58	127.85 ± 49.00	84.26 ± 17.64	88.87 ± 15.72	141.17 ± 27.21	111.44 ± 15.95
Long Beach, California - LBHCA						
Naphthalene	29/29	120.00 ± 45.46	NA	NA	NA	NA
Rubidoux, California - RUCA						
Naphthalene	58/58	81.55 ± 18.46	39.34 ± 10.71	59.18 ± 11.11	138.90 ± 43.53	81.40 ± 16.05
San Jose, California - SJJCA						
Arsenic (PM ₁₀)	56/60	0.49 ± 0.19	0.20 ± 0.12	0.28 ± 0.09	1.06 ± 0.33	0.52 ± 0.13
Naphthalene	59/59	148.08 ± 57.34	41.70 ± 11.59	32.48 ± 8.67	149.43 ± 41.24	93.97 ± 22.27
Nickel (PM ₁₀)	60/60	1.52 ± 0.59	1.07 ± 0.30	1.24 ± 0.35	1.77 ± 0.41	1.40 ± 0.21

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations for the California monitoring sites from Table 7-5 include the following:

- Naphthalene was identified as a pollutant of interest for all four sites. Concentrations of naphthalene were highest at CELA and lowest at RUCA, based on the annual averages. LBHCA does not have an annual average presented in Table 7-5 because

sampling was discontinued at this site at the end of July 2013. However, summary statistics for LBHCA covering the sampling period are provided in Appendix M.

- For each site except LBHCA, naphthalene concentrations appear highest during the first and fourth quarters of 2013, based on the quarterly averages. However, the confidence intervals calculated for the quarterly averages indicate that there is considerable variability in the measurements.
- Naphthalene concentrations measured at CELA range from 23.20 ng/m³ to 332.5 ng/m³ with a median concentration of 92.2 ng/m³. All but one of CELA's 12 naphthalene concentrations greater than 150 ng/m³ was measured during either the first or fourth quarter of 2013. However, both the maximum and minimum naphthalene concentrations measured at CELA were measured in January. This helps explain the large confidence interval shown for CELA's first quarter naphthalene concentration.
- The confidence interval for the third quarter average concentration of benzo(a)pyrene for CELA is greater than the average itself, indicating a high level of variability associated with the measurements. The two maximum concentrations measured at CELA were measured during the third quarter (0.627 ng/m³ measured on July 27, 2013 and 0.371 ng/m³ measured on September 13, 2013). Only two additional measured detections of benzo(a)pyrene were measured at CELA during the third quarter; the other 11 were non-detects, which is the highest number of non-detects of benzo(a)pyrene for a given quarter at CELA.
- The maximum concentrations of acenaphthene and fluorene were measured at CELA on the same date, September 7, 2013. Several of the higher measurements of these two pollutants were measured on the same date. The magnitude of the concentrations of these pollutants tend to track each other.
- Concentrations of naphthalene measured at LBHCA range from 12.7 ng/m³ to 270 ng/m³, with a median concentration of 41.90 ng/m³. Because this site completed sampling in July, an annual average could not be calculated. In addition, no second quarter average is presented in Table 7-5 because there were a number of invalid samples (five) and the quarterly criteria was not met. All seven naphthalene concentrations greater than 100 ng/m³ were measured in January or February while all 10 concentrations less than 30 ng/m³ were measured between late April and July.
- Concentrations of naphthalene at RUCA also tended to be higher during the colder months of the year. Not only are the first and fourth quarter averages higher than the other quarterly averages, they also have more variability associated with them, particularly the fourth quarter average concentration. All six naphthalene concentrations greater than 150 ng/m³ measured at RUCA were measured during the fourth quarter of 2013. Concentrations measured during the first and fourth quarters range from 47.75 ng/m³ to 404 ng/m³ with a median concentration of 88.2 ng/m³. Concentrations measured during the second and third quarters range from 20.85 ng/m³ to 100 ng/m³ with a median concentration of 43.2 ng/m³.

- Naphthalene concentrations measured at SJJCA follow a similar pattern as those measured at RUCA. The first and fourth quarter naphthalene averages are significantly higher than the other quarterly averages, and they too have more variability associated with them. All 10 naphthalene concentrations greater than 150 ng/m³ measured at SJJCA were measured during the first or fourth quarters of 2013, with the three concentrations greater than 300 ng/m³ all measured in January. Concentrations measured during the first and fourth quarters range from 41.0 ng/m³ to 377 ng/m³ with a median concentration of 121 ng/m³. Concentrations measured during the second and third quarters range from 14.5 ng/m³ to 91.7 ng/m³ with a median concentration of 34.5 ng/m³.
- The fourth quarter average concentration of arsenic for SJJCA is significantly higher than the other quarterly averages shown in Table 7-5. A review of the data shows that all six arsenic concentrations greater than 1 ng/m³ were measured during the fourth quarter, with the three highest concentrations all measured in late December. Further, the 15 highest concentrations were all measured during the first or fourth quarters of 2013. Conversely, all eight concentrations less than or equal to 0.1 ng/m³ were measured during the second or third quarters of 2013, as were three of the four non-detects.
- Concentrations of nickel measured at SJJCA range from 0.36 ng/m³ to 4.66 ng/m³, with a median concentration of 1.14 ng/m³. Although the highest quarterly average concentration is the fourth quarter average, the first quarter average has the highest confidence interval associated with it, indicating considerable variability associated with the measurements. The maximum nickel concentration measured at SJJCA (4.66 ng/m³) was measured on February 27, 2013; the next highest concentration measured that quarter was half as high (2.31 ng/m³ measured on January 4, 2013). Three additional nickel concentrations greater than 1.50 ng/m³ were also measured during the first quarter; yet, three of the 10 lowest concentrations were measured during the first quarter.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the California sites from those tables include the following:

- CELA, RUCA, and SJJCA each appear in Table 4-11 for naphthalene, ranking fourth, tenth, and sixth, respectively. CELA also ranks eighth for acenaphthene.
- SJJCA appears twice in Table 4-12 for PM₁₀ metals. SJJCA has the sixth highest annual average concentration of nickel and tenth highest annual average concentration of arsenic among NMP sites sampling PM₁₀ metals.

7.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 7-4 for CELA, RUCA, and SJJCA. Figures 7-12 through 7-17 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1. Because annual averages could not be calculated for LBHCA, box plots were not created for this site.

Figure 7-12. Program vs. Site-Specific Average Acenaphthene Concentration

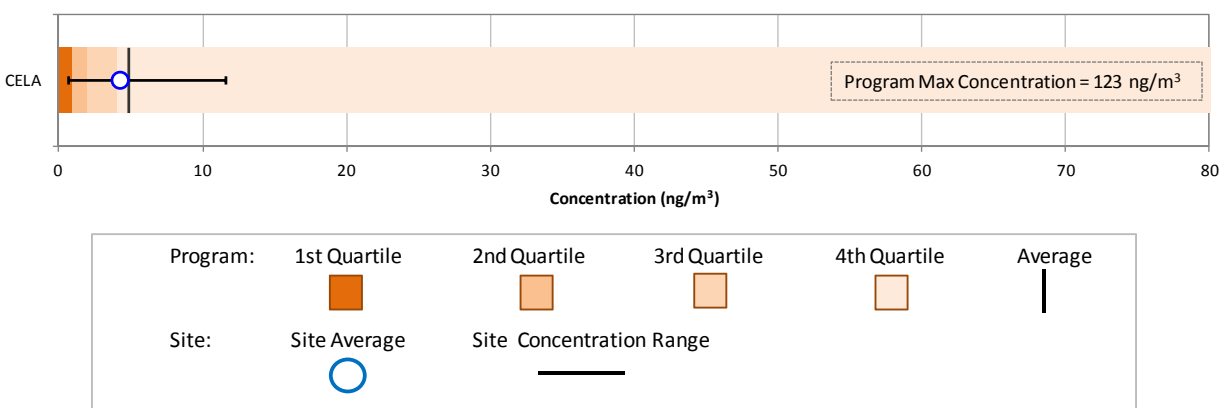


Figure 7-13. Program vs. Site-Specific Average Arsenic (PM₁₀) Concentration

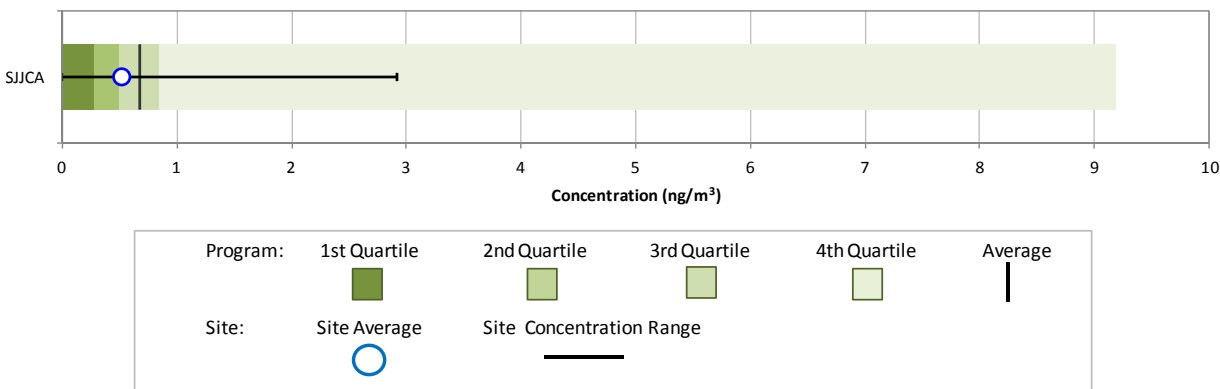


Figure 7-14. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

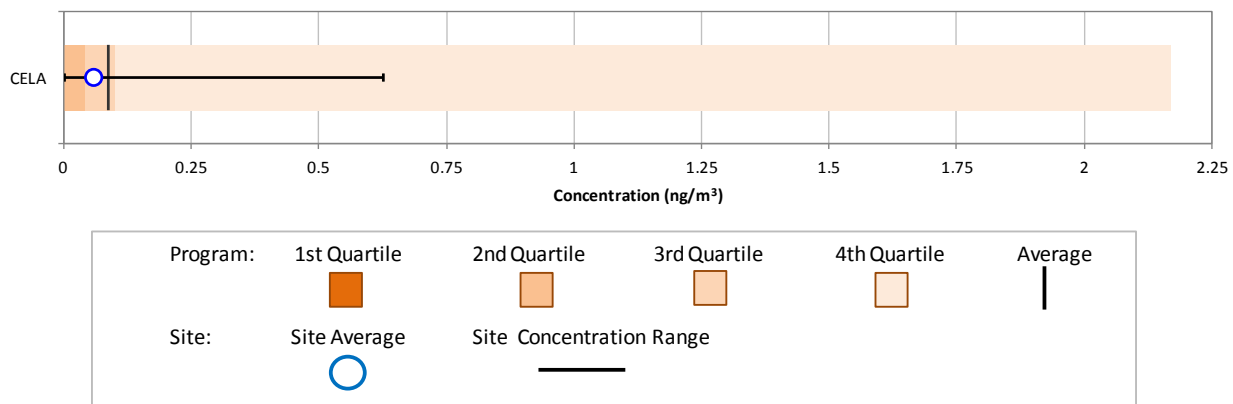


Figure 7-15. Program vs. Site-Specific Average Fluorene Concentration

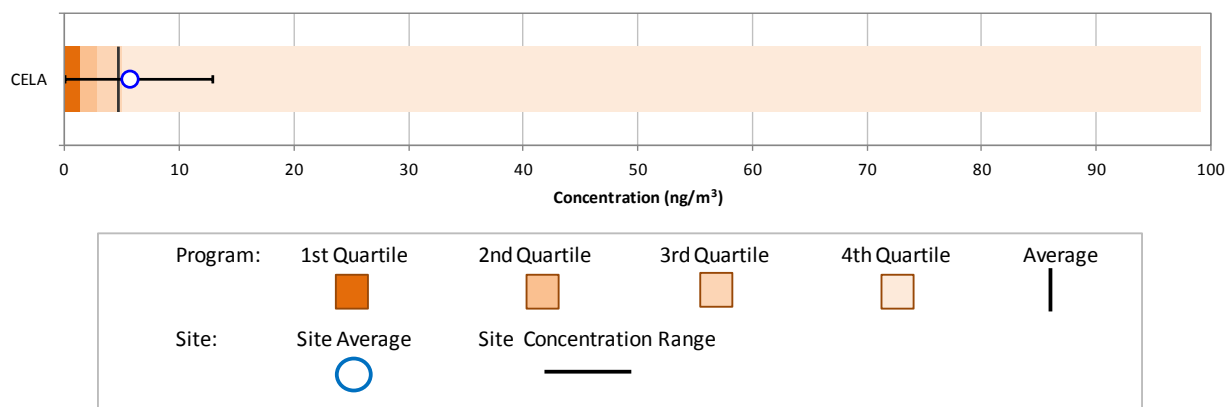


Figure 7-16. Program vs. Site-Specific Average Naphthalene Concentrations

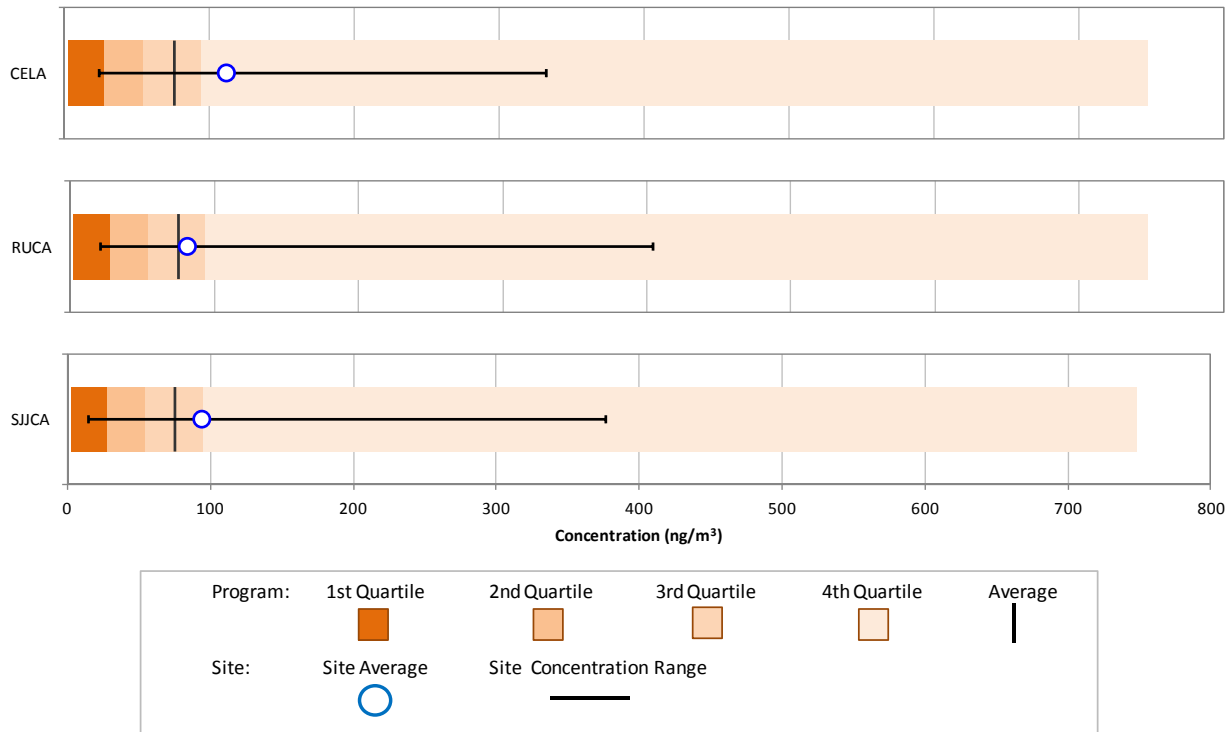
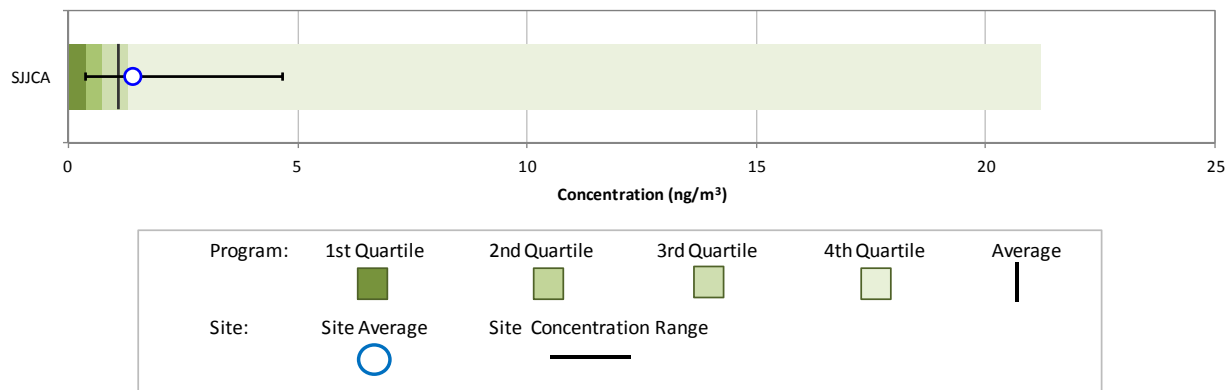


Figure 7-17. Program vs. Site-Specific Average Nickel (PM₁₀) Concentration



Observations from Figures 7-12 through 7-17 include the following:

- Figure 7-12 is the box plot for acenaphthene for CELA. Note that the program-level maximum concentration (123 ng/m³) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 80 ng/m³. Figure 7-12 shows the maximum acenaphthene concentration measured at CELA is an order of magnitude less than the program-level maximum concentration. CELA's annual average concentration is just less than the program-level average concentration and just greater than the program-level third quartile.

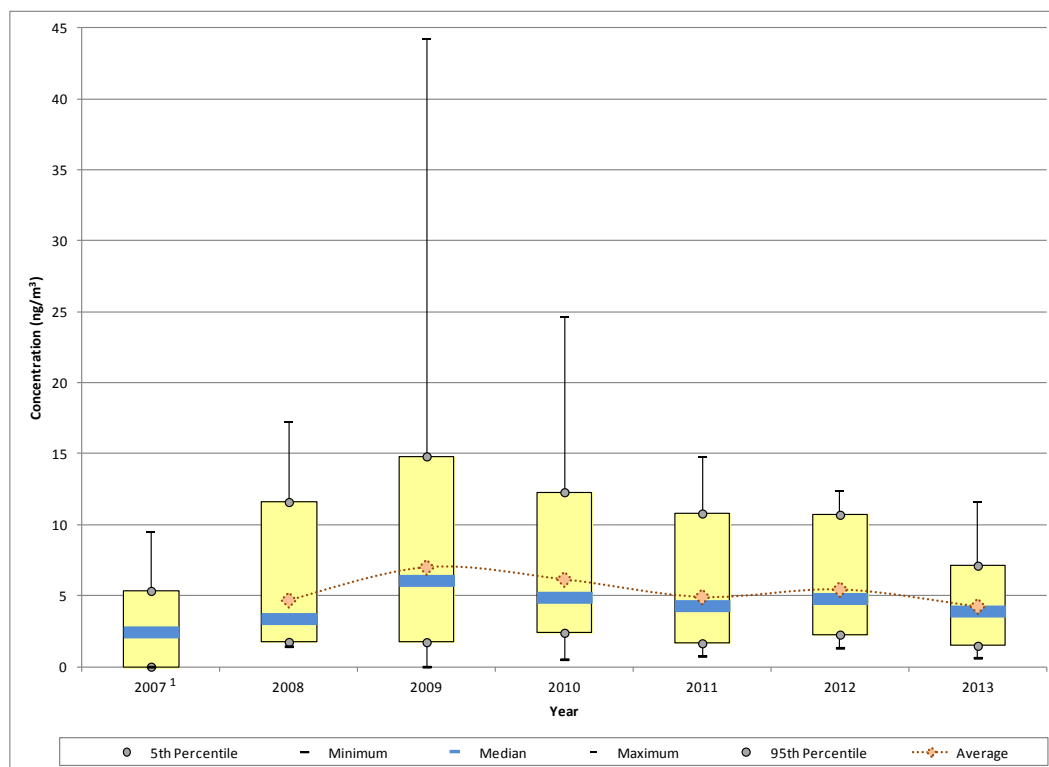
- Figure 7-13 shows that the annual average arsenic (PM₁₀) concentration for SJJCA is less than the program-level average concentration and similar to the median concentration of arsenic (PM₁₀). The minimum concentration measured at SJJCA is zero, indicating that at least one non-detect of arsenic was measured at SJJCA; four non-detects of arsenic were measured at SJJCA.
- Figure 7-14 is the box plot for benzo(a)pyrene for CELA. Note that the program-level first quartile is zero and therefore not visible on the box plot. The annual average benzo(a)pyrene for CELA falls right between the program-level median and average concentrations of this pollutant. Note that CELA is one of only two NMP sites for which benzo(a)pyrene is a pollutant of interest.
- Figure 7-15 for fluorene shows that the range of fluorene concentrations measured at CELA is relatively small compared to the range measured across the program, yet CELA's annual average is greater than the program-level average and third quartile. This is the result of non-detects. Of the 174 non-detects of fluorene measured across the program, only one was measured at CELA. CELA ties with three other sites for the second lowest number of fluorene non-detects (only S4MO had none).
- Figure 7-16 for naphthalene shows all three sites with available annual averages. The box plots make an inter-site comparison relatively easy; the annual average concentration is highest for CELA, followed by SJJCA and RUCA, although the largest range of concentrations was measured at RUCA. All three annual average naphthalene concentrations shown are greater than the program-level average concentration. SJJCA's annual average is also similar to the program-level third quartile and CELA's annual average concentration is greater than the program-level third quartile. There were no non-detects of naphthalene measured at CELA, RUCA, SJJCA, or across the program.
- Figure 7-17 is the box plot for nickel for SJJCA. SJJCA's annual average nickel concentration is greater than the program-level average concentration and just greater than the program-level third quartile, although the maximum concentration measured at SJJCA is considerably less than the maximum concentration measured across the program. The minimum nickel concentration measured at SJJCA is similar to the program-level first quartile.

7.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. Both CELA and RUCA began sampling PAHs under the NMP in 2007. SJJCA began sampling PAHs and metals under the NMP in 2008. Thus, Figures 7-18 through 7-25 present the 1-year statistical metrics for each of the pollutants of interest first for CELA, then for RUCA, and finally for SJJCA. The statistical metrics presented for assessing trends include the substitution

of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented. A trends analysis was not conducted for LBHCA because this site has not sampled under the NMP for at least 5 consecutive years.

Figure 7-18. Yearly Statistical Metrics for Acenaphthene Concentrations Measured at CELA



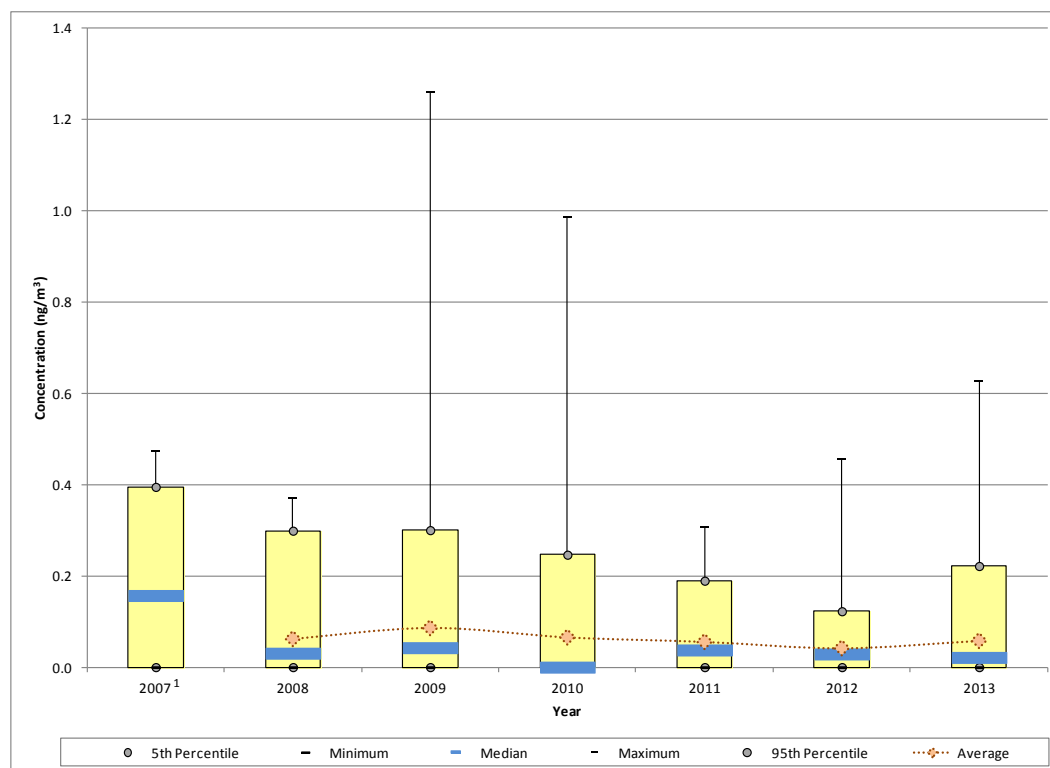
¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2007.

Observations from Figure 7-18 for acenaphthene measurements collected at CELA include the following:

- CELA began sampling PAHs under the NMP in April 2007. Because a full year's worth of data is not available, a 1-year average concentration for 2007 is not presented, although the range of measurements is provided.
- The maximum acenaphthene concentration was measured at CELA on October 16, 2009 and is the only concentration greater than 25 ng/m³ measured at this site.
- Acenaphthene concentrations measured at CELA increased significantly between 2007 and 2009, as indicated by nearly all of the statistical metrics shown. With the exception of the minimum concentration, each of the statistical metrics exhibits a decreasing trend between 2009 and 2011.

- Excluding 2007, the maximum, 95th percentile, and 1-year average concentrations are at a minimum for 2013. 2013 has the smallest difference between the 5th and 95th percentiles since 2007, indicating that the majority of measurements are falling within a smaller range of concentrations.

Figure 7-19. Yearly Statistical Metrics for Benzo(a)pyrene Concentrations Measured at CELA



¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2007.

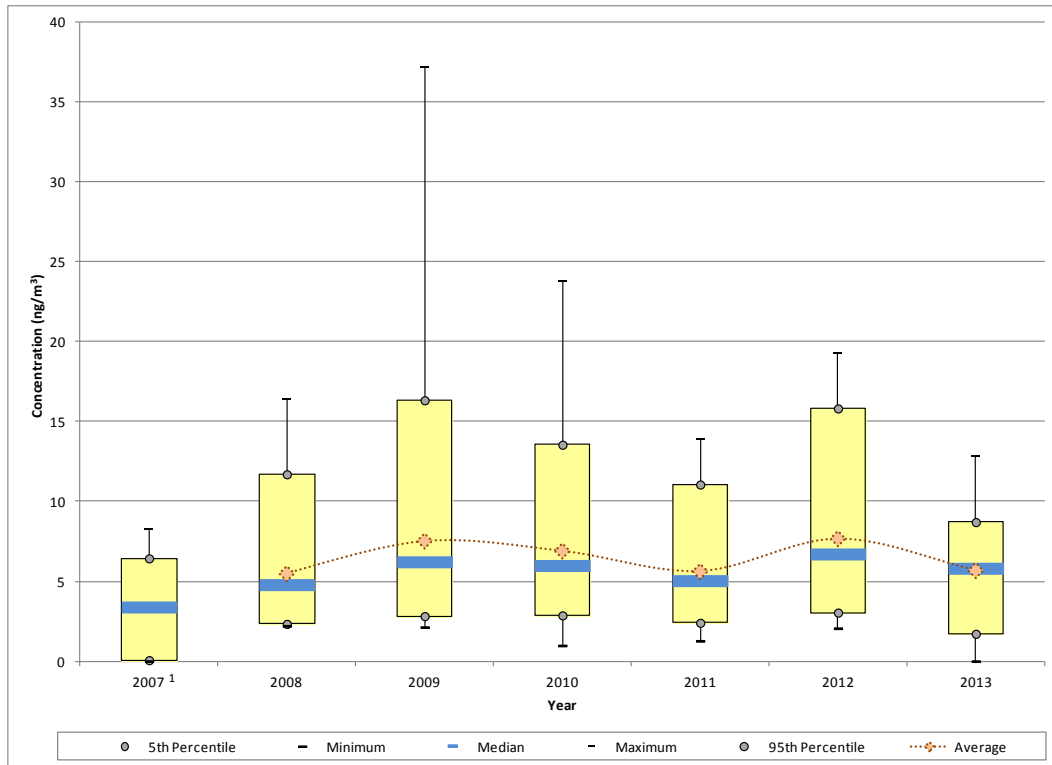
Observations from Figure 7-19 for benzo(a)pyrene measurements collected at CELA include the following:

- The maximum benzo(a)pyrene concentration was measured at CELA on January 1, 2009 and is the only concentration greater than 1 ng/m³ measured at this site, although two benzo(a)pyrene concentrations close to 1 ng/m³ were measured at CELA in 2010. The fourth highest benzo(a)pyrene concentration measured at CELA is the maximum concentration for 2013 (0.627 ng/m³).
- With the exception of the maximum concentration for 2009, the range of concentrations measured at CELA in 2008 and 2009 is fairly similar. The increase in the 1-year average concentration shown is mostly a result of the maximum concentration. Excluding the maximum concentration from the 1-year average for 2009 results in an average concentration very similar to that of 2008.
- The median concentration for 2010 is zero, indicating that at least half of the measurements were non-detects. The number of non-detects increased each year from

2007 through 2010, reaching a maximum of 41 non-detects in 2010. As a result, even though the second and third highest concentrations of benzo(a)pyrene were measured at CELA in 2010, each of the statistical parameters exhibits a decrease from the previous year. Further decreases in the statistical metrics are shown for 2011 (even though fewer non-detects (18) were measured) and 2012 (although the maximum concentration is up).

- Several of the statistical metrics exhibit increases for 2013, although the median concentration continues its decreasing trend. The decrease in the median concentrations result from the increasing number of non-detects, which increased from 18 in 2011 to 22 in 2012 and 26 in 2013 while the increase in the 1-year average concentrations result from a higher number of concentrations at the upper end of the range. For example, in 2012, only one concentration greater than 0.2 ng/m³ was measured at CELA; in 2013, that number increased to five (the most since 2009).

Figure 7-20. Yearly Statistical Metrics for Fluorene Concentrations Measured at CELA



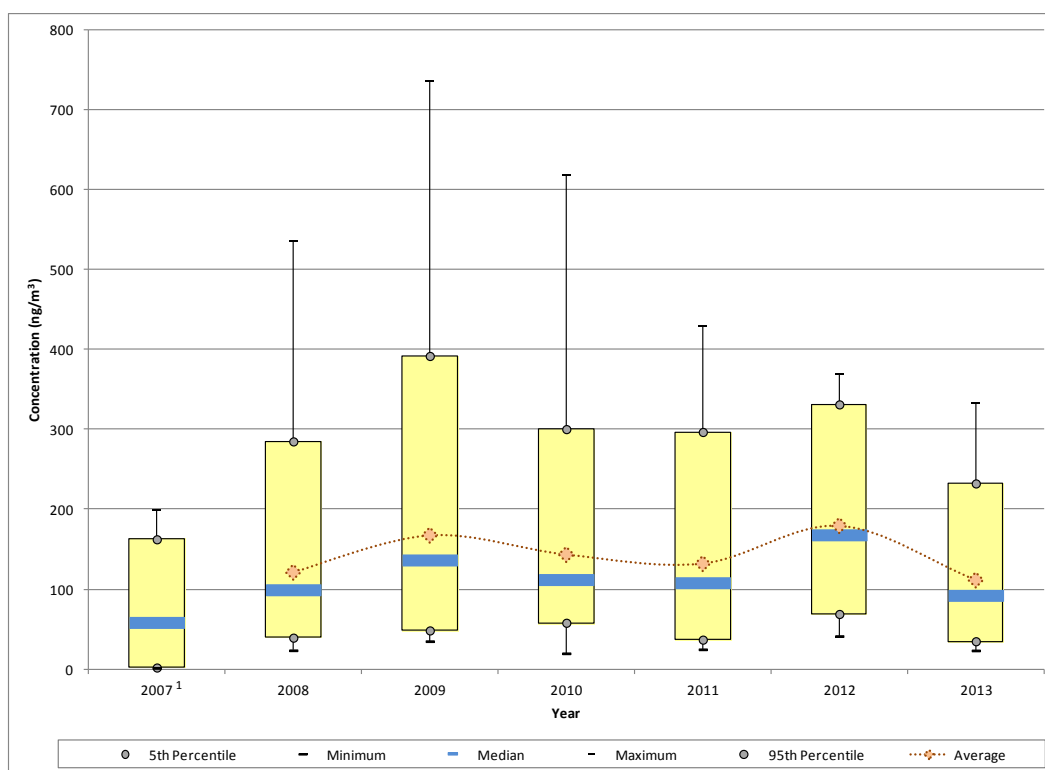
¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2007.

Observations from Figure 7-20 for fluorene measurements collected at CELA include the following:

- The smallest range of fluorene measurements was collected in 2007, although the statistical metrics do not represent a full year of sampling. This was also the only year a non-detect was measured until the a second non-detect was measured in 2013.

- The range of concentrations measured, and thus the statistical parameters shown, increased through 2009, when the maximum fluorene concentration was measured (on the same date that the maximum acenaphthene concentration was measured). The maximum concentration for 2009 is the only measurement greater than 25 ng/m³ measured at this site. The maximum, 95th percentile, 1-year average, and median concentrations decrease from 2009 to 2010 and again for 2011. Concentrations measured in 2011 have the smallest range of measurements besides 2007 (which was a partial year).
- All of the statistical parameters exhibit an increase from 2011 to 2012 then exhibit decreases for 2013.

Figure 7-21. Yearly Statistical Metrics for Naphthalene Concentrations Measured at CELA



¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2007.

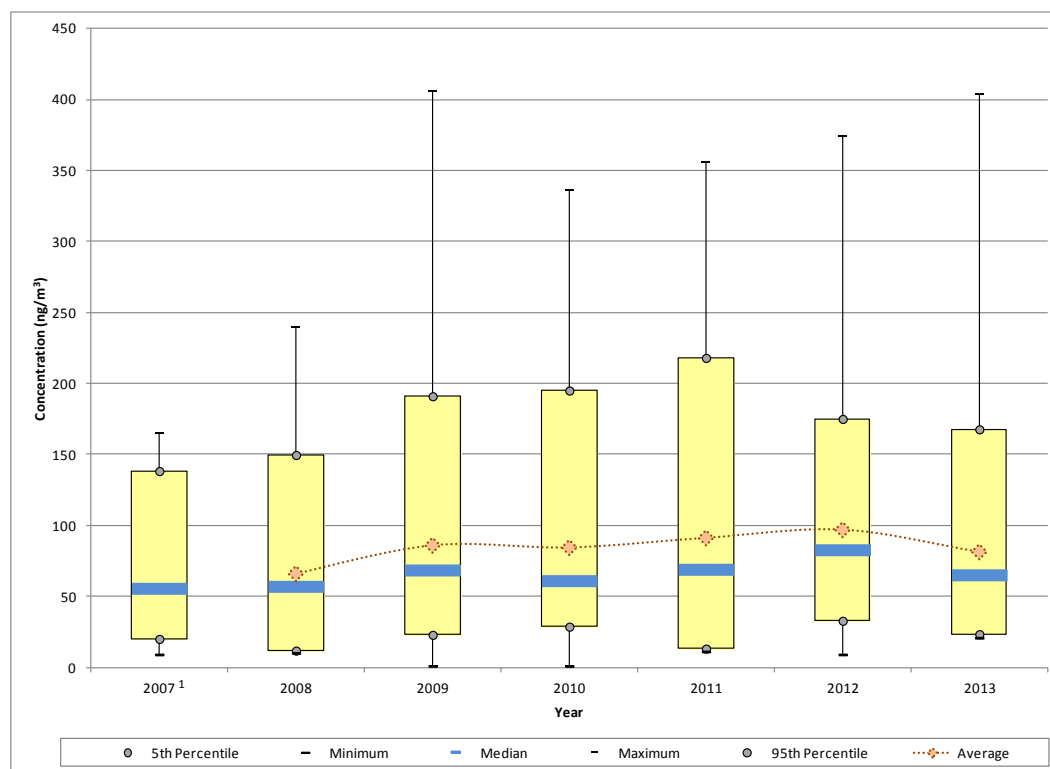
Observations from Figure 7-21 for naphthalene measurements collected at CELA include the following:

- The statistical parameters shown for naphthalene in Figure 7-21 exhibit a similar pattern as the statistical parameters for fluorene shown in Figure 7-20 and, to a less extent, acenaphthene in Figure 7-18.
- The smallest range of concentrations was measured in 2007, although the statistical metrics do not represent a full year of sampling. The minimum concentration measured at CELA was measured in 2007 (1.30 ng/m³); in addition, 2007 is the only

year in which a concentration less than 10 ng/m³ was measured (there were five in total). The range of naphthalene measurements, and thus the statistical parameters shown, increase through 2009, when the maximum concentration was measured (736 ng/m³ also on October 16, 2009). Concentrations greater than 500 ng/m³ were also measured in 2008 and 2010. The maximum, 95th percentile, 1-year average, and median concentrations decrease from 2009 to 2010 and again for 2011.

- All of the statistical parameters shown in Figure 7-21 exhibit an increase from 2011 to 2012 except the maximum concentration. The increase in the 1-year average concentration from 2011 to 2012 is significant, even though the range of concentrations measured in 2012 is the smallest since the initial year of sampling.
- With the exception of the minimum concentration, all of the statistical metric shown in Figure 7-21 are at a minimum for 2013 since the first full year of sampling.

Figure 7-22. Yearly Statistical Metrics for Naphthalene Concentrations Measured at RUCA



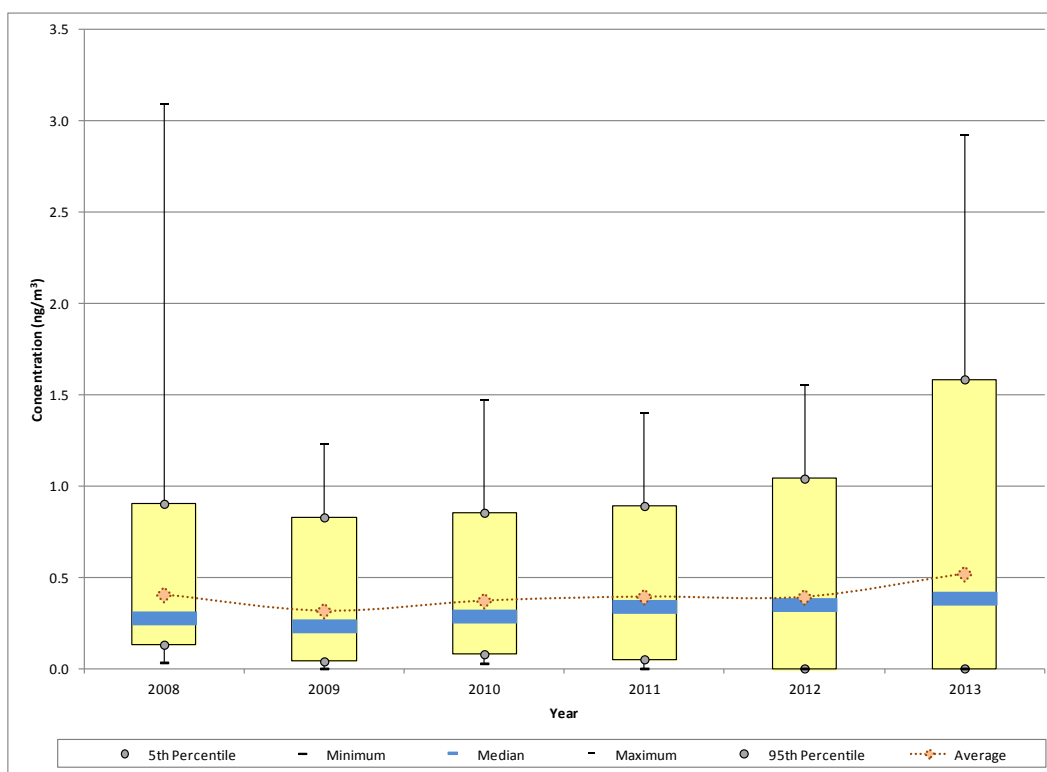
¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2007.

Observations from Figure 7-22 for naphthalene measurements collected at RUCA include the following:

- RUCA began sampling PAHs under the NMP in May 2007. Because a full year's worth of data is not available, a 1-year average is not presented, although the range of measurements is provided.

- The smallest range of measurements was collected in 2007, although the statistical metrics do not represent a full year of sampling.
- The maximum naphthalene concentration was measured at RUCA in 2009 (406 ng/m³), although another concentration greater than 400 ng/m³ was measured at RUCA in 2013. Naphthalene concentrations greater than 300 ng/m³ have been measured at least once every year since 2009.
- The 1-year average concentration has an increasing trend over most of the years of sampling through 2012, although 2010 was down slightly. The median concentration has a similar pattern.
- The range of concentrations measured at RUCA reflects a relatively high level of variability in the measurements collected. For both 2009 and 2013, the maximum concentration is twice the 95th percentile. Even though the majority of concentrations measured in 2012 fall within a tighter range of measurements than preceding years, the 1-year average concentration is still higher for 2012 than 2011, due in part to the maximum concentration measured. However, the 20 percent increase shown in the median concentration indicates that concentrations were higher overall for 2012.
- Even with the second highest naphthalene concentration measured since the onset of sampling at RUCA, most of the statistical parameters exhibit a decrease for 2013.

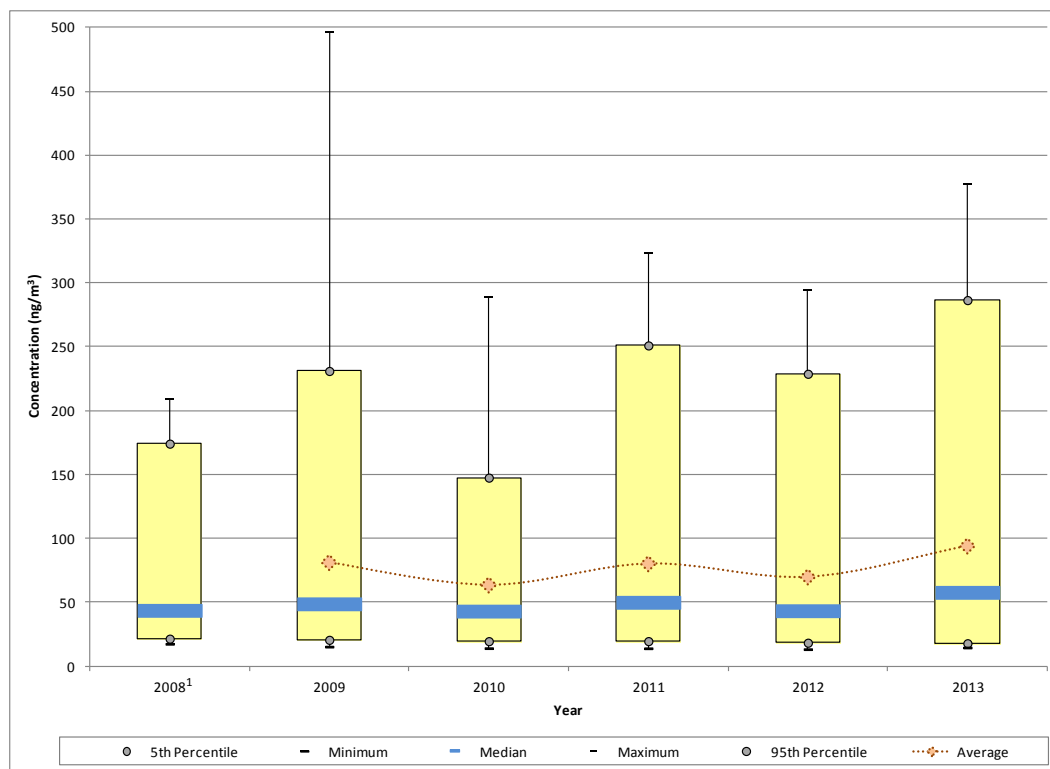
Figure 7-23. Yearly Statistical Metrics for Arsenic (PM₁₀) Concentrations Measured at SJJCA



Observations from Figure 7-23 for arsenic measurements collected at SJJCA include the following:

- The maximum concentration of arsenic was measured on the first day of sampling at SJJCA (January 1, 2008). The second and third highest concentrations were measured in 2013. All but one of the seven concentrations greater than 1.5 ng/m³ were measured in 2008 (two) or 2013 (four).
- The 1-year average arsenic concentration decreased from 2008 to 2009. Although this is mostly due to the maximum concentration measured in 2008, all of the statistical parameters exhibit a decrease from 2008 to 2009, indicating that the decrease is not only due to the difference in the maximum concentrations. The number of concentrations at the lower end of the concentration range increased for 2009. In 2009, two non-detects were measured at SJJCA, compared to none in 2008. In addition, seven arsenic concentrations less than 0.1 ng/m³ were measured in 2009 compared to only two in 2008.
- The 1-year average arsenic concentration changed little through 2012, ranging from 0.31 ng/m³ for 2009 to 0.39 ng/m³ for 2012. With the exception of the minimum and 5th percentile (which did not change), all of the statistical metrics exhibit an increase for 2013. The 95th percentile for 2013 is greater than the maximum concentration measured for all years except 2008.

Figure 7-24. Yearly Statistical Metrics for Naphthalene Concentrations Measured at SJJCA

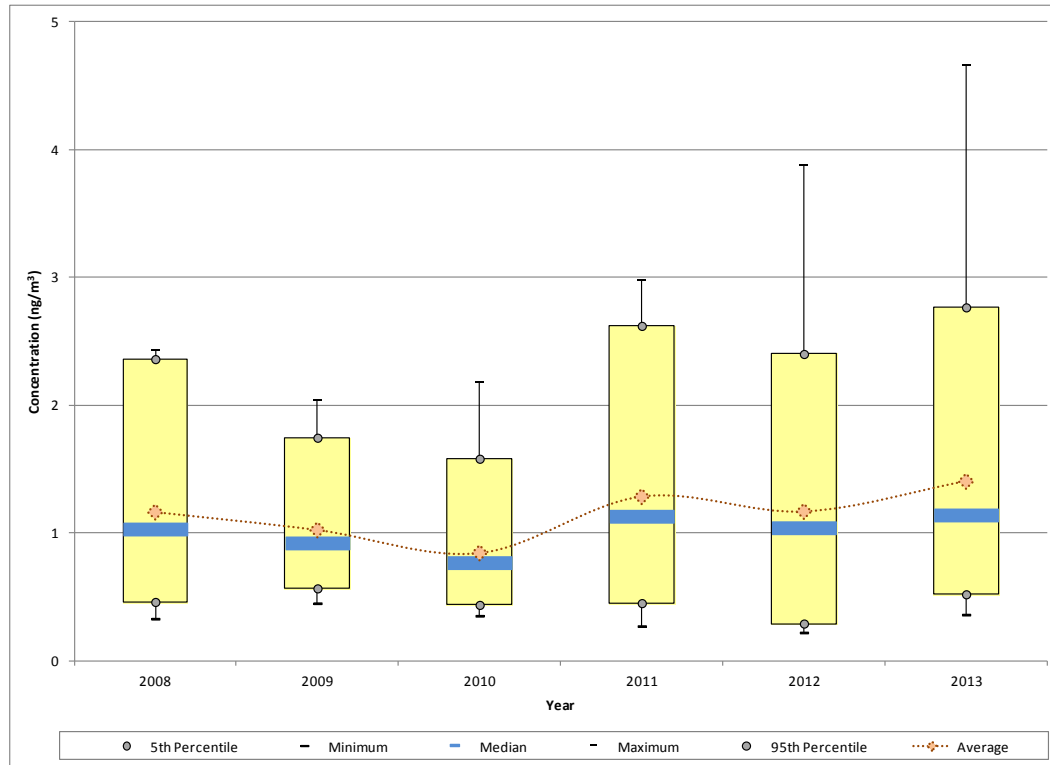


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2008.

Observations from Figure 7-24 for naphthalene measurements collected at SJJCA include the following:

- SJJCA began sampling PAHs under the NMP in May 2008. Because a full year's worth of data is not available, a 1-year average is not presented, although the range of measurements is provided.
- The maximum concentration of naphthalene was measured at SJJCA in 2009 (496 ng/m³). No additional concentrations greater than 400 ng/m³ have been measured at SJJCA.
- The median concentration has changed little over the years through 2012, ranging from 43.00 ng/m³ (2010) to 49.90 ng/m³ (2011); 2013 is the first year with a median concentration greater than 50 ng/m³ (57.70 ng/m³). The 1-year average concentration exhibits more variability, ranging from 63.44 ng/m³ (2010) to 81.04 ng/m³ (2009) through 2012, then increasing to 93.97 ng/m³ for 2013.
- There is very little change among the minimum concentrations and 5th percentiles across the years of sampling while there are significant fluctuations in the statistical parameters representing the upper end of the concentration range. For example, the 95th percentile increased by 70 percent from 2010 to 2011.

Figure 7-25. Yearly Statistical Metrics for Nickel (PM₁₀) Concentrations Measured at SJJCA



Observations from Figure 7-25 for nickel measurements collected at SJJCA include the following:

- The maximum concentration of nickel was measured on February 27, 2013. All of the 14 measurements greater than or equal to 2.5 ng/m³ were measured after 2010, specifically, five in 2011, three in 2012, and five in 2013.
- After a significant decrease between 2008 and 2010, the 1-year average nickel concentration increased significantly from 2010 to 2011. This trend is reflected in the median concentrations as well. The 95th percentile for 2011 is greater than the maximum concentration measured in previous years.
- Even though the maximum concentration increased from 2011 to 2012, most of the statistical metrics exhibit decreases for 2012. Four of the five nickel concentrations less than 0.30 ng/m³ were measured in 2012. The minimum concentration decreased by half between 2009 and 2012.
- Each of the statistical metrics shown in Figure 7-25 exhibits an increase for 2013. Four of the six statistical parameters are at a maximum for 2013 (only the minimum concentration and 5th percentile are not).

7.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at each California monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

7.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the California monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 7-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 7-6. Risk Approximations for the California Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Los Angeles, California - CELA						
Acenaphthene	0.000088	--	58/58	4.26 ± 0.54	0.37	--
Benzo(a)pyrene	0.00176	--	32/58	0.06 ± 0.03	0.10	--
Fluorene	0.000088	--	57/58	5.67 ± 0.57	0.50	--
Naphthalene	0.000034	0.003	58/58	111.44 ± 15.95	3.79	0.04
Long Beach, California - LBHCA						
Naphthalene	0.000034	0.003	29/29	NA	NA	NA
Rubidoux, California - RUCA						
Naphthalene	0.000034	0.003	58/58	81.40 ± 16.05	2.77	0.03
San Jose, California - SJJCA						
Arsenic (PM ₁₀)	0.0043	0.000015	56/60	0.52 ± 0.13	2.22	0.03
Naphthalene	0.000034	0.003	59/59	93.97 ± 22.27	3.19	0.03
Nickel (PM ₁₀)	0.00048	0.00009	60/60	1.40 ± 0.21	0.67	0.02

-- = A Cancer URE or Noncancer RfC is not available.

NA = Not available due to the criteria for calculating an annual average.

Observations for the California sites from Table 7-6 include the following:

- Naphthalene has the highest annual average concentration for each of the California monitoring sites among the site-specific pollutants of interest, as discussed in the previous section. The annual average concentration CELA is the highest of the three annual averages for naphthalene, followed by the annual average for SJJCA and RUCA.
- Naphthalene also has the highest cancer risk approximation among the site-specific pollutants of interest for the California monitoring sites. The cancer risk approximations range from 2.77 in-a-million for RUCA to 3.79 in-a-million for CELA.
- None of the other pollutants of interest for CELA have cancer risk approximations greater than 1 in-a-million.
- Even though the annual average concentration of nickel is nearly three times greater than the annual average concentration of arsenic for SJJCA, arsenic has the higher cancer risk approximation (2.22 in-a-million) compared to nickel (0.67 in-a-million).

- All of the noncancer hazard approximations for the pollutants of interest for the California monitoring sites are less than 1.0, where noncancer RfCs are available, indicating that no adverse noncancer health effects are expected from these individual pollutants.
- Cancer risk and noncancer hazard approximations could not be calculated for LBHCA due to the mid-year end date of sampling, as discussed in the previous sections.

7.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 7-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 7-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 7-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 7-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 7-7. Table 7-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. Thus, LBHCA does not have cancer risk and noncancer hazard approximations in Tables 7-7 and 7-8. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 7.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 7-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the California Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Los Angeles, California (Los Angeles County) - CELA					
Formaldehyde	2,221.45	Formaldehyde	2.89E-02	Naphthalene	3.79
Benzene	1,913.13	POM, Group 1a	1.49E-02	Fluorene	0.50
Dichloromethane	1,682.67	Benzene	1.49E-02	Acenaphthene	0.37
Ethylbenzene	1,101.33	1,3-Butadiene	9.87E-03	Benzo(a)pyrene	0.10
Tetrachloroethylene	1,076.88	POM, Group 2b	7.27E-03		
Acetaldehyde	962.00	POM, Group 5a	6.02E-03		
p-Dichlorobenzene	339.36	POM, Group 2d	5.84E-03		
1,3-Butadiene	328.83	Naphthalene	5.27E-03		
POM, Group 1a	169.60	p-Dichlorobenzene	3.73E-03		
Naphthalene	154.91	Hexavalent Chromium	3.03E-03		
Long Beach, California (Los Angeles County) - LBHCA					
Formaldehyde	2,221.45	Formaldehyde	2.89E-02		
Benzene	1,913.13	POM, Group 1a	1.49E-02		
Dichloromethane	1,682.67	Benzene	1.49E-02		
Ethylbenzene	1,101.33	1,3-Butadiene	9.87E-03		
Tetrachloroethylene	1,076.88	POM, Group 2b	7.27E-03		
Acetaldehyde	962.00	POM, Group 5a	6.02E-03		
p-Dichlorobenzene	339.36	POM, Group 2d	5.84E-03		
1,3-Butadiene	328.83	Naphthalene	5.27E-03		
POM, Group 1a	169.60	p-Dichlorobenzene	3.73E-03		
Naphthalene	154.91	Hexavalent Chromium	3.03E-03		

Table 7-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the California Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Rubidoux, California (Riverside County) - RUCA					
Formaldehyde	418.81	Formaldehyde	5.44E-03	Naphthalene	2.77
Benzene	317.30	Benzene	2.47E-03		
Tetrachloroethylene	214.39	Hexavalent Chromium	2.04E-03		
Dichloromethane	200.68	POM, Group 1a	1.88E-03		
Acetaldehyde	197.01	1,3-Butadiene	1.47E-03		
Ethylbenzene	191.03	POM, Group 2b	1.45E-03		
p-Dichlorobenzene	70.48	POM, Group 5a	1.20E-03		
1,3-Butadiene	48.84	Naphthalene	1.19E-03		
Naphthalene	34.99	POM, Group 2d	1.09E-03		
1,3-Dichloropropene	29.57	p-Dichlorobenzene	7.75E-04		
San Jose, California (Santa Clara County) - SJCA					
Benzene	356.17	Formaldehyde	4.46E-03	Naphthalene	3.19
Formaldehyde	342.81	Benzene	2.78E-03	Arsenic	2.22
Ethylbenzene	232.74	POM, Group 2b	1.73E-03	Nickel	0.67
Dichloromethane	191.47	Hexavalent Chromium	1.67E-03		
Acetaldehyde	171.62	POM, Group 5a	1.63E-03		
Tetrachloroethylene	110.40	1,3-Butadiene	1.35E-03		
p-Dichlorobenzene	60.37	POM, Group 2d	1.32E-03		
1,3-Butadiene	45.07	Naphthalene	1.26E-03		
Naphthalene	37.18	POM, Group 1a	1.21E-03		
Trichloroethylene	29.51	p-Dichlorobenzene	6.64E-04		

Table 7-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the California Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Los Angeles, California (Los Angeles County) - CELA					
Toluene	8,265.39	Acrolein	6,797,409.70	Naphthalene	0.04
1,1,1-Trichloroethane	6,903.37	Chlorine	230,010.81		
Xylenes	4,970.97	Formaldehyde	226,678.82		
Hexane	4,520.90	1,3-Butadiene	164,416.69		
Formaldehyde	2,221.45	Acetaldehyde	106,888.65		
Benzene	1,913.13	Benzene	63,771.13		
Dichloromethane	1,682.67	Cyanide Compounds, PM	63,440.92		
Ethylene glycol	1,465.20	Trichloroethylene	56,352.54		
Methanol	1,338.85	Naphthalene	51,636.02		
Ethylbenzene	1,101.33	Xylenes	49,709.73		
Long Beach, California (Los Angeles County) - LBHCA					
Toluene	8,265.39	Acrolein	6,797,409.70		
1,1,1-Trichloroethane	6,903.37	Chlorine	230,010.81		
Xylenes	4,970.97	Formaldehyde	226,678.82		
Hexane	4,520.90	1,3-Butadiene	164,416.69		
Formaldehyde	2,221.45	Acetaldehyde	106,888.65		
Benzene	1,913.13	Benzene	63,771.13		
Dichloromethane	1,682.67	Cyanide Compounds, PM	63,440.92		
Ethylene glycol	1,465.20	Trichloroethylene	56,352.54		
Methanol	1,338.85	Naphthalene	51,636.02		
Ethylbenzene	1,101.33	Xylenes	49,709.73		

Table 7-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the California Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Rubidoux, California (Riverside County) - RUCA					
Toluene	1,541.54	Acrolein	1,151,923.43	Naphthalene	0.03
Xylenes	1,037.06	Chlorine	71,489.03		
Hexane	1,034.89	Formaldehyde	42,736.21		
1,1,1-Trichloroethane	617.84	1,3-Butadiene	24,417.60		
Formaldehyde	418.81	Acetaldehyde	21,889.50		
Benzene	317.30	Bromomethane	13,246.82		
Ethylene glycol	241.17	Naphthalene	11,663.14		
Methanol	218.85	Lead, PM	11,143.30		
Tetrachloroethylene	214.39	Benzene	10,576.82		
Dichloromethane	200.68	Trichloroethylene	10,486.48		
San Jose, California (Santa Clara County) - SJJCA					
Toluene	1,762.28	Acrolein	1,804,553.18	Arsenic	0.03
1,1,1-Trichloroethane	1,289.63	Chlorine	91,338.84	Naphthalene	0.03
Hexane	1,014.84	Formaldehyde	34,980.53	Nickel	0.02
Xylenes	987.31	1,3-Butadiene	22,537.16		
Benzene	356.17	Acetaldehyde	19,068.78		
Formaldehyde	342.81	Trichloroethylene	14,754.18		
Ethylene glycol	280.57	Naphthalene	12,392.06		
Ethylbenzene	232.74	Benzene	11,872.49		
Methanol	216.21	Xylenes	9,873.13		
Dichloromethane	191.47	Lead, PM	9,571.88		

Observations from Table 7-7 include the following:

- Formaldehyde and benzene are the highest emitted pollutants with cancer UREs in Los Angeles and Riverside Counties while benzene is emitted in slightly higher quantities than formaldehyde in Santa Clara County. The quantity of emissions is considerably greater for Los Angeles County than Riverside and Santa Clara Counties.
- Formaldehyde has the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for all three counties. POM, Group 1, benzene, and 1,3-butadiene rank behind formaldehyde for Los Angeles County; benzene, hexavalent chromium, and POM, Group 1 rank behind formaldehyde for Riverside County; and benzene, POM, Group 2b, and hexavalent chromium rank behind formaldehyde for Santa Clara County.
- Six of the highest emitted pollutants also have the highest toxicity-weighted emissions for Los Angeles County, while there are five in common for Riverside and Santa Clara Counties.
- Naphthalene has the highest cancer risk approximation for all three sites for which annual averages could be calculated. Naphthalene appears on both emissions-based lists for all three counties.
- Arsenic and nickel, the other pollutants of interest for SJJCA, do not appear on either emissions-based list (they rank lower than tenth). Hexavalent chromium is the only metal shown for Santa Clara County, ranking fourth highest for its toxicity-weighted emissions.
- Several POM Groups appear among the pollutants with the highest toxicity-weighted emissions for each county. POM, Group 2b includes acenaphthene and fluorene, which were both identified as pollutants of interest for CELA. POM, Group 2d includes several PAHs sampled for at the California sites, such as anthracene and phenanthrene, although none of these failed screens. POM, Group 5a includes benzo(a)pyrene, which failed screens for CELA and RUCA. POM, Group 1a, which also appears among each county's toxicity-weighted emissions, includes unspciated compounds.

Observations from Table 7-8 include the following:

- Toluene is the highest emitted pollutant with a noncancer RfC in all three California counties. The quantity emitted is significantly higher for Los Angeles County than Riverside and Santa Clara Counties. 1,1,1-Trichloroethane is the second highest emitted pollutant in Los Angeles and Santa Clara Counties but ranks fourth for Riverside County. Xylenes are the second highest emitted pollutant in Riverside County but ranks third and fourth for Los Angeles and Santa Clara Counties, respectively. Hexane is also among the top four emitted pollutants in each of these counties.

- Acrolein, chlorine, formaldehyde, 1,3-butadiene, and acetaldehyde are the five pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for all three counties. Although acrolein and chlorine rank highest for toxicity-weighted emissions for each county, neither pollutant appears among the highest emitted. This is also true for acetaldehyde, and 1,3-butadiene. Conversely, formaldehyde has the fifth highest emissions for each county.
- Three of the highest emitted pollutants also have the highest toxicity-weighted emissions for Los Angeles and Santa Clara Counties, while only two of the highest emitted pollutants also have the highest toxicity-weighted emissions for Riverside County.
- Naphthalene is the only pollutant for which a noncancer hazard approximation could be calculated for all three counties. Naphthalene does not appear among the highest emitted pollutants (of those with a noncancer RfC) for any of the three counties. Naphthalene ranks seventh for its toxicity-weighted emissions for Riverside and Santa Clara Counties and ninth for Los Angeles County.
- Arsenic and nickel are the only other pollutants of interest for SJJCA for which noncancer hazard approximations could be calculated. Lead is the only metal that appears on either emissions-based list for Santa Clara County in Table 7-8. This pollutant failed a single screen for SJJCA but was not identified as a pollutant of interest for this site.

7.6 Summary of the 2013 Monitoring Data for the California Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *Naphthalene failed screens for all four California sites. Three additional PAHs failed screens for CELA and one additional PAH failed screens for RUCA. One additional PAH and four PM₁₀ metals failed screens for SJJCA.*
- ❖ *Naphthalene had the highest annual average concentration among the site-specific pollutants of interest for each of the California monitoring sites. CELA has the fourth highest annual average concentration of naphthalene among NMP sites sampling PAHs.*
- ❖ *Concentrations of naphthalene were higher during the first and fourth quarters (or the colder months) of 2013 for CELA, RUCA, and SJJCA.*
- ❖ *Concentrations of each of the pollutants of interest for SJJCA increased from 2012 to 2013, particularly for the metals.*
- ❖ *Naphthalene has the highest cancer risk approximation of the pollutants of interest for each site. None of the pollutants of interest for the California sites have noncancer hazard approximations greater than an HQ of 1.0.*

8.0 Sites in Colorado

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Colorado, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

8.1 Site Characterization

This section characterizes the Colorado monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The NATTS site in Colorado is located in Grand Junction (GPCO) while the other five sites are located in Garfield County, between 38 miles and 76 miles northeast of Grand Junction, in the towns of Battlement Mesa (BMCO), Silt (BRCO), Parachute (PACO), Carbondale (RFCO), and Rifle (RICO). Figure 8-1 for GPCO is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 8-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 8-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Figures 8-3 through 8-9 are the composite satellite maps and emissions sources maps for the Garfield County sites. Table 8-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 8-1. Grand Junction, Colorado (GPCO) Monitoring Site



Figure 8-2. NEI Point Sources Located Within 10 Miles of GPCO

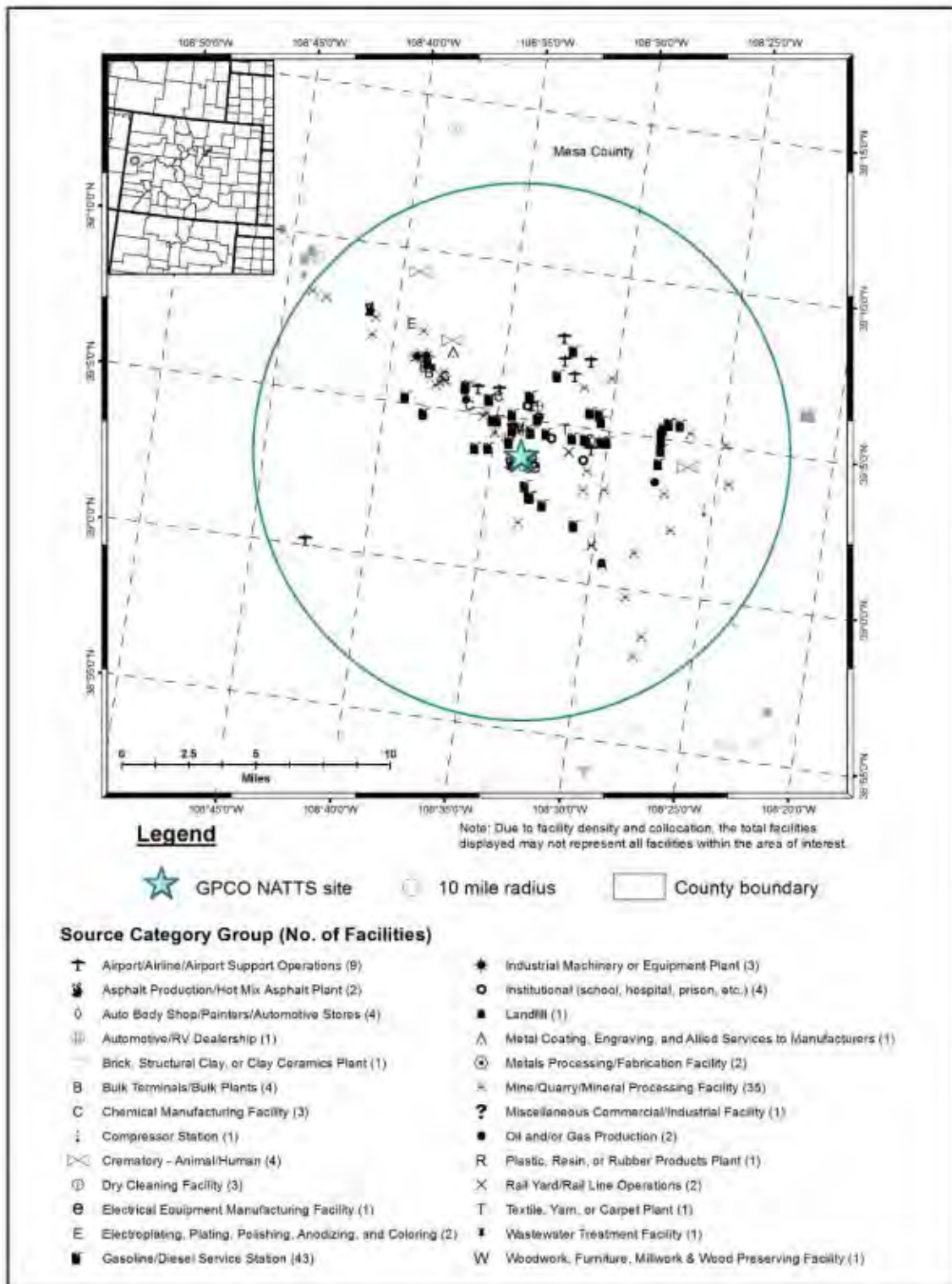


Figure 8-3. Battlement Mesa, Colorado (BMCO) Monitoring Site



Figure 8-4. Silt, Colorado (BRCO) Monitoring Site

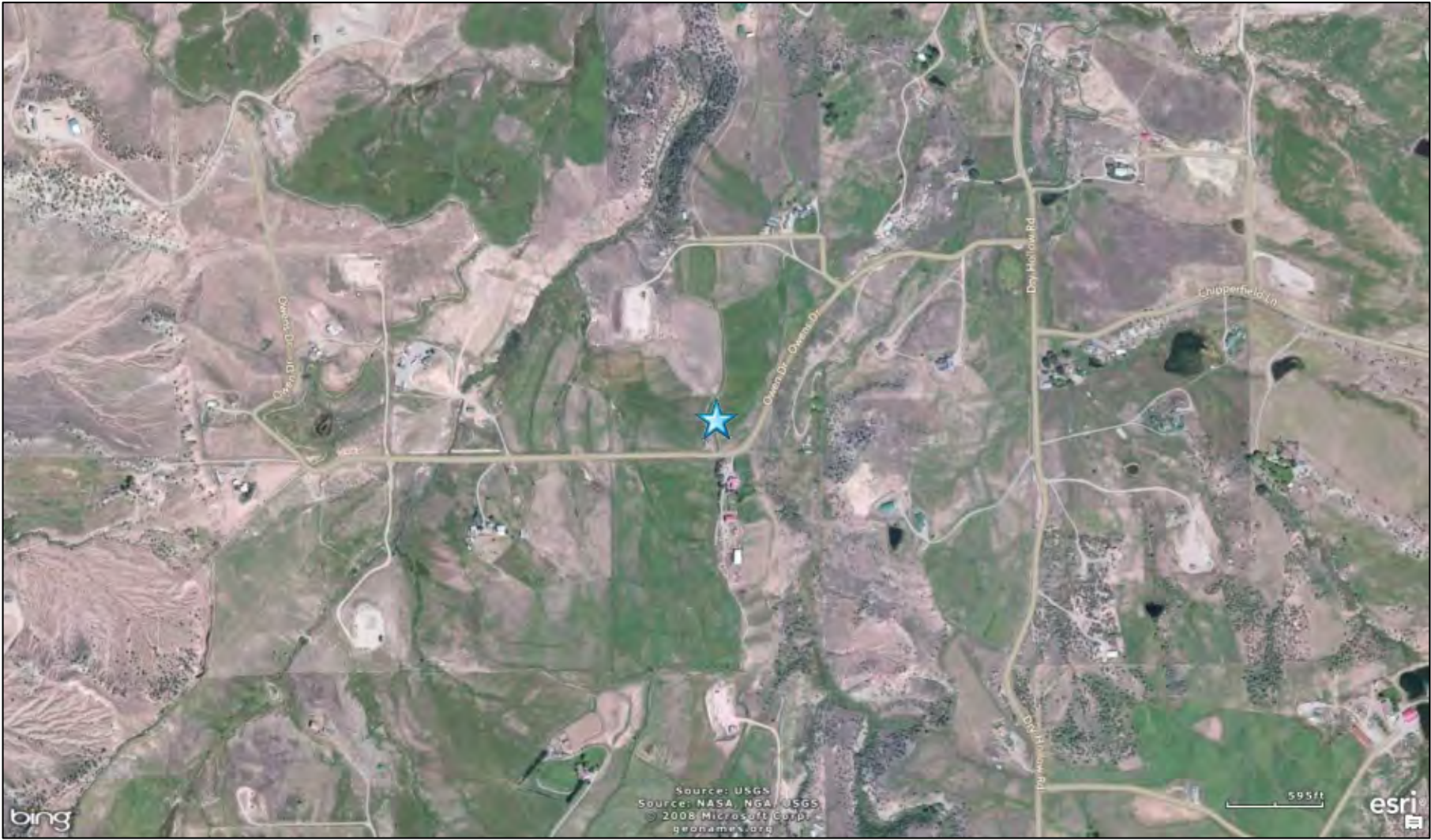


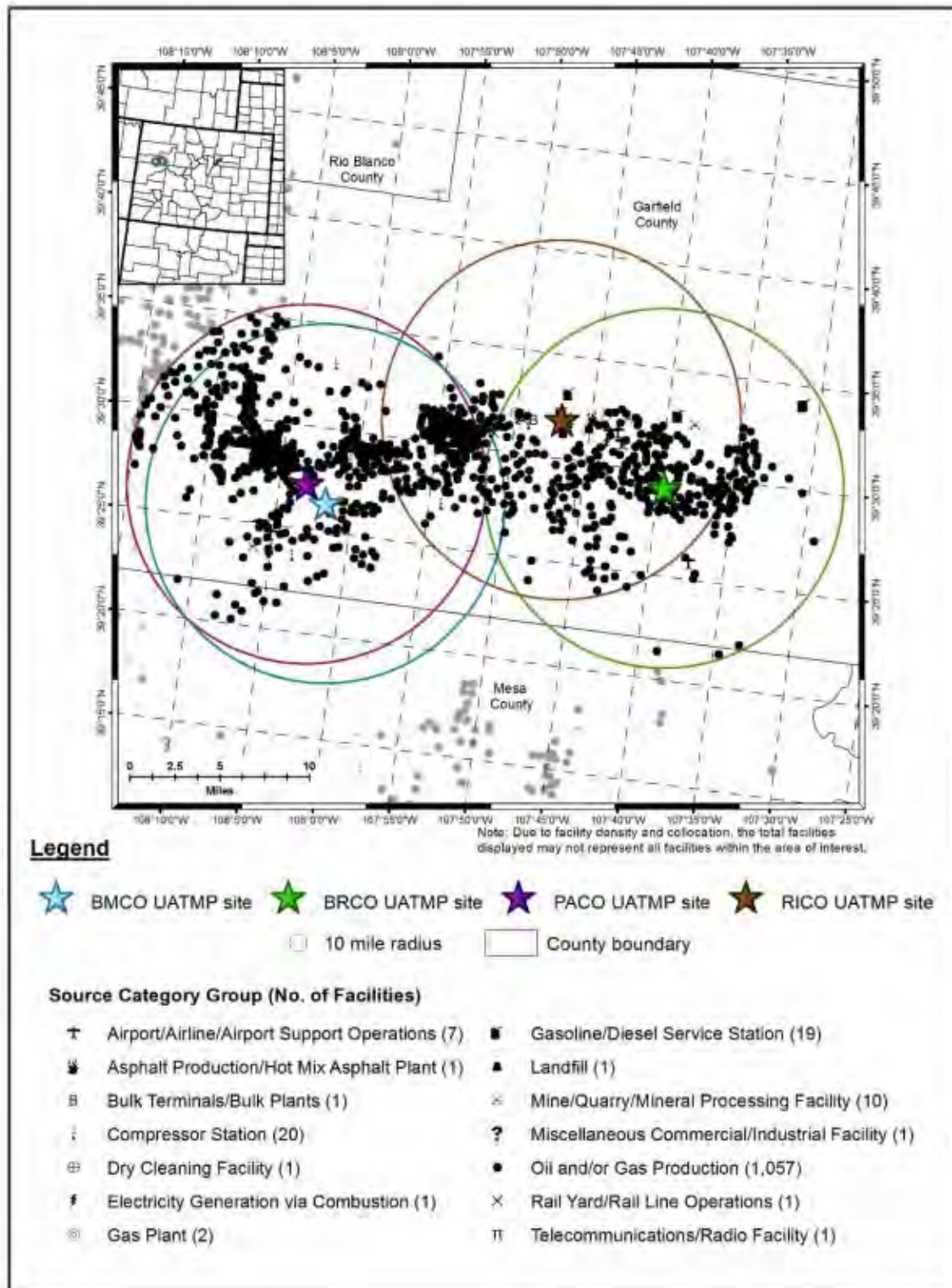
Figure 8-5. Parachute, Colorado (PACO) Monitoring Site



Figure 8-6. Rifle, Colorado (RICO) Monitoring Site



Figure 8-7. NEI Point Sources Located Within 10 Miles of BMCO, BRCO, PACO, and RICO



6-8



Figure 8-9. NEI Point Sources Located Within 10 Miles of RFCO

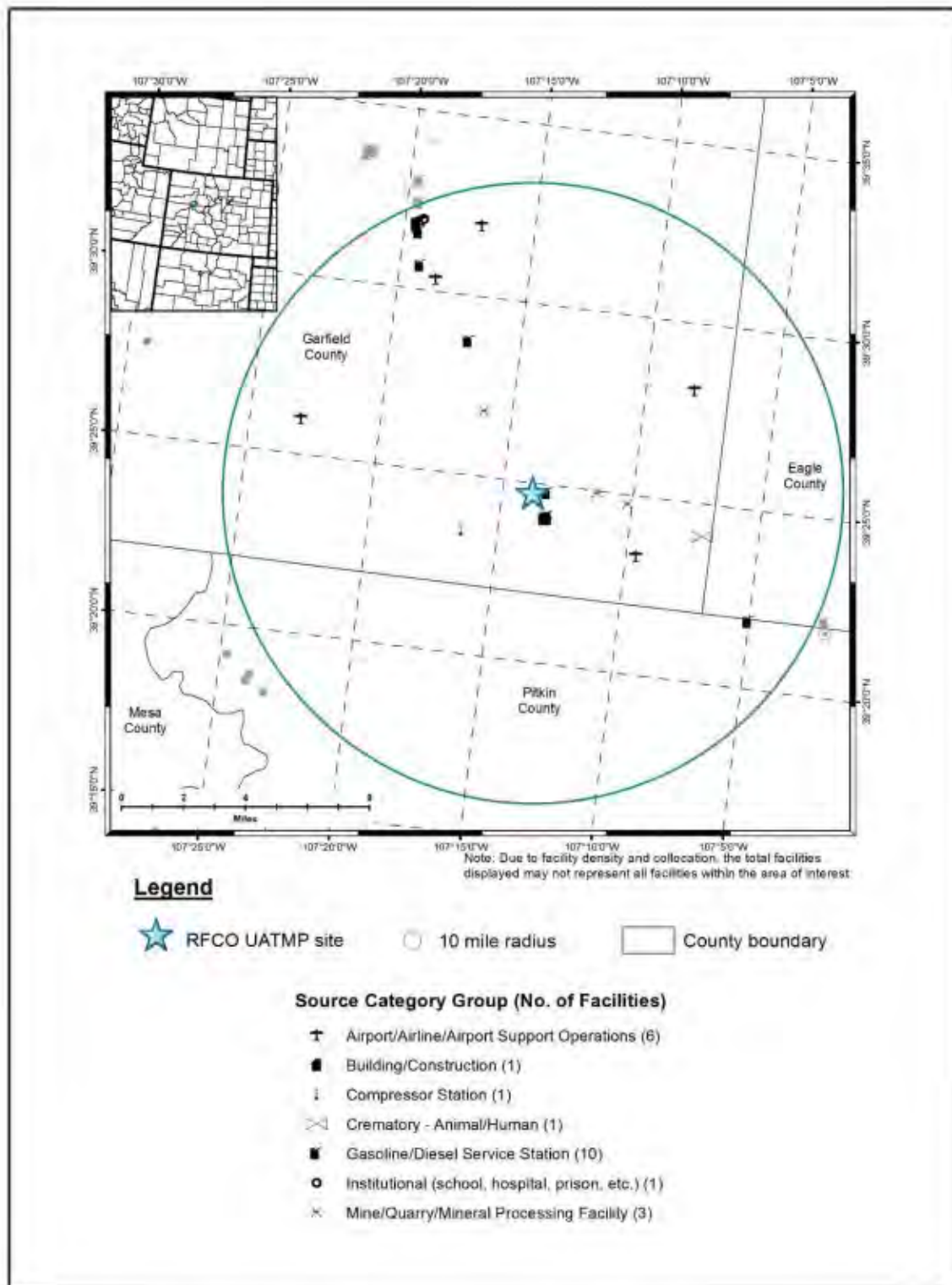


Table 8-1. Geographical Information for the Colorado Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>GPCO</i>	08-077-0017 08-077-0018	Grand Junction	Mesa	Grand Junction, CO	39.064289, -108.56155	Commercial	Urban/City Center	Meteorological parameters, CO, PM ₁₀ , PM ₁₀ Speciation, PM Coarse, PM _{2.5} , and PM _{2.5} Speciation, IMPROVE Speciation.
BMCO	08-045-0019	Battlement Mesa	Garfield	Glenwood Springs, CO	39.438060, -108.026110	Commercial	Suburban	Meteorological parameters, PM ₁₀ , PM _{2.5} , O ₃ , NO, NO ₂ , NO _x , TNMOC, and Total Hydrocarbons.
BRCO	08-045-0009	Silt	Garfield	Glenwood Springs, CO	39.487755, -107.659685	Agricultural	Rural	None.
PACO	08-045-0005	Parachute	Garfield	Glenwood Springs, CO	39.453654, -108.053259	Residential	Urban/City Center	PM ₁₀ .
RICO	08-045-0007	Rifle	Garfield	Glenwood Springs, CO	39.531813, -107.782298	Commercial	Urban/City Center	PM ₁₀ .
RFCO	08-045-0018	Carbondale	Garfield	Glenwood Springs, CO	39.412278, -107.230397	Residential	Rural	PM ₁₀ .

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The GPCO monitoring site is comprised of two locations. The first location is a small 1-story shelter that houses the VOC and carbonyl compound samplers, with the PAH sampler located just outside the shelter. The second location, which is on the roof of an adjacent 2-story building, is comprised of the hexavalent chromium samplers. As a result, two AQS codes are provided in Table 8-1. Figure 8-1 shows that the area surrounding GPCO is of mixed usage, with commercial businesses to the west, northwest, and north; residential areas to the northeast and east; and industrial areas to the southeast, south, and southwest. This site's location is next to one of the major east-west roads in Grand Junction (I-70 Business). A railroad runs east-west a few blocks to the south of the GPCO monitoring site, and merges with another railroad to the southwest of the site. The Colorado River can be seen in the bottom left-hand corner of Figure 8-1 near the junction with the Gunnison River. Grand Junction is located in the Grand Valley, which lies north and northeast of the Colorado National Monument.

As Figure 8-2 shows, GPCO is located within 10 miles of numerous emissions sources. Many of the sources are located along a diagonal line running roughly northwest to southeast along Highways 6 and 50 and Business-70 and oriented along the mountain valley. Many of the point sources near GPCO fall into the gasoline/diesel service station or the mine/quarry/mineral processing source categories. The sources closest to GPCO are an industrial machinery/equipment plant, a bulk terminal/bulk plant, a gasoline/diesel service station, and an auto body shop.

Four of the five Garfield County monitoring sites are situated in towns located along a river valley along the Colorado River and paralleling I-70. The BMCO monitoring site is located in Battlement Mesa, a rural community located to the southeast of Parachute. The monitoring site is located on the roof of the Grand Valley Fire Protection District facility, near the intersection of Stone Quarry Road and West Battlement Parkway, as shown in Figure 8-3. The site is surrounded primarily by residential subdivisions. A gas station is located immediately to the north of the site and a cemetery is located to the south.

The BRCO monitoring site is located on Bell/Melton Ranch, off Owens Drive, approximately 4 miles south of the town of Silt. The site is both rural and agricultural in nature. As shown in Figure 8-4, the closest major roadway is County Road 331, Dry Hollow Road.

PACO is located on the roof of the old Parachute High School building, which is presently operating as a day care facility. This location is in the center of the town of Parachute. The surrounding area is considered residential. Interstate-70 is less than a quarter of a mile from the monitoring site, as shown in Figure 8-5. PACO is located 1.6 miles from BMCO, which are the Garfield County sites that are the closest to each other.

RICO is located on the roof of the Henry Annex Building in downtown Rifle. This location is near the crossroads of several major roadways through town, as shown in Figure 8-6. Highway 13 and US-6/24 intersect just south of the site and I-70 is just over a half-mile south of the monitoring site, across the Colorado River. The surrounding area is considered commercial.

These four Garfield County sites are located along a line running roughly east-west and spanning approximately 20 miles; hence, they are shown together in Figure 8-7. There are more than 1,000 petroleum or natural gas wells (collectively shown as the oil and/or gas production source category) within 10 miles of these sites. One reason Garfield County is conducting air monitoring is to characterize the effects these wells may have on the air quality in the surrounding areas (GCPH, 2014).

The RFCO monitoring site is the only site in Garfield County not located along the I-70 corridor. This site is located in the southeast corner of Garfield County in Carbondale. The town of Carbondale resides in a valley between the Roaring Fork and Crystal Rivers, north of Mt. Sopris (Carbondale, 2015). The RFCO monitoring site is located near the boathouse of the Rocky Mountain School on the bank of the Crystal River in the northern part of town. The surrounding area is considered residential and rural. Highway 82, which runs southward from Glenwood Springs and separates Carbondale from the base of Red Hill, is just over one-third of a mile north of RFCO and is visible in the top right-hand corner of Figure 8-8.

Because RFCO is 24 miles from the next closest Garfield County monitoring site, the emissions sources surrounding RFCO are provided in a separate map in Figure 8-9. This figure shows that the few emissions sources within 10 miles of RFCO are primarily gasoline and/or diesel service stations. There is also a building/construction company, a compressor station, three mine/quarry/mineral processing facilities, and an airport within a few miles of this site.

Table 8-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Colorado monitoring sites. Table 8-2 includes both county-level population and vehicle registration information. Table 8-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 8-2 presents the county-level daily VMT for Mesa and Garfield Counties. Because VMT from the state of Colorado is available for state highways only, VMT presented in this table is from the 2011 NEI, version 2.

Table 8-2. Population, Motor Vehicle, and Traffic Information for the Colorado Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
<i>GPCO</i>	Mesa	147,554	176,969	11,000	Bus-70 (Pitkin Ave) just E of 7th St	3,355,813
BMCO	Garfield	57,302	74,036	1,880	S Battlement Pkwy	2,171,019
BRCO				1,182	Dry Hollow Rd	
PACO				15,000	I-70 near exit 75	
RFCO				16,000	Rt 133 just south of Hwy 82	
RICO				15,000	Rt 13 connecting US-6 and I-70	

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect 2012 data (CO DOR, 2013)

³AADT reflects 2013 data for GPCO, PACO, RFCO, and RICO (CO DOT, 2013a) and 2014 data for BMCO and BRCO (GCRBD, 2014)

⁴County-level VMT reflects 2011 data (EPA, 2015a)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 8-2 include the following:

- Mesa County's population and vehicle ownership are considerably higher than those for Garfield County. However, both counties rank in the bottom-third compared to other counties with NMP sites.
- The traffic volumes near RICO, RFCO, PACO, and GPCO are considerably higher than the traffic volumes near BMCO and BRCO. Yet, the traffic volumes for all six Colorado sites rank in the bottom half compared to the traffic volumes for other NMP sites. The traffic volume for BRCO is one of the lowest among all NMP sites. However, this monitoring site is located in the most rural of settings compared to the other Colorado sites.
- While more than 1 million miles separate the Mesa County and Garfield County VMTs, as obtained from the 2011 NEI, version 2, they are also both in the bottom-third among VMTs for counties with NMP sites.

8.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Colorado on sample days, as well as over the course of the year.

8.2.1 Climate Summary

Grand Junction is located in a mountain valley on the west side of the Rockies. The mountains surrounding the valley help protect the city from dramatic weather changes. The area tends to be sunny and fairly dry, with annual precipitation amounts less than 10 inches. On average, one to two snowfalls occur during each of the winter months, but tend to be short-lived in duration. Winds tend to flow out of the east-southeast on average, due to the valley breeze effect (Wood, 2004). Valley breezes occur as the sun heats up the side of a mountain; the warm air rises, creating a current that will move up the valley walls (Boubel, et al., 1994).

The towns of Battlement Mesa, Parachute, Rifle, and Silt are located to the northeast of Grand Junction, across the county line and along the I-70 corridor. These towns are located along a river valley running north of the Grand Mesa. The town of Carbondale is farther east, in a river valley in the southeast corner of Garfield County. Similar to Grand Junction, these towns are shielded from drastic changes in weather by the surrounding terrain and tend to experience fairly dry conditions for most of the year. Wind patterns in these towns are affected by the canyons, the Colorado River and its tributaries, and valley breezes (GCPH, 2014; WRCC, 2014).

8.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the Colorado monitoring sites (NCDC, 2013), as described in Section 3.4.2. The weather station nearest GPCO is located at Walker Field Airport (WBAN 23066). The closest weather station to four of the five Garfield County sites is located at Garfield County Regional Airport (WBAN 03016) while the weather station closest to RFCO is located at Aspen-Pitkin County Airport (WBAN 93073). Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 8-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 8-3. Average Meteorological Conditions near the Colorado Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Grand Junction, Colorado - GPCO									
Walker Field/Grand Junction Regional Airport 23066 (39.13, -108.54)	5.0 miles	Sample Day (67)	61.3 ± 6.1	49.2 ± 5.7	27.1 ± 3.4	38.5 ± 4.0	52.7 ± 6.0	1016.5 ± 2.5	6.0 ± 0.7
	13° (NNE)	2013	61.7 ± 2.5	49.9 ± 2.3	28.7 ± 1.5	39.6 ± 1.7	54.0 ± 2.5	1016.3 ± 1.0	5.9 ± 0.3
Battlement Mesa, Colorado - BMCO									
Garfield County Regional Airport 03016 (39.53, -107.72)	17.7 miles	Sample Day (58)	63.0 ± 6.1	48.4 ± 5.5	28.0 ± 3.5	38.4 ± 4.0	53.8 ± 4.8	1017.0 ± 2.4	4.9 ± 0.8
	70° (ENE)	2013	60.6 ± 2.4	46.8 ± 2.2	27.5 ± 1.5	37.5 ± 1.6	55.3 ± 1.9	1017.8 ± 0.9	4.6 ± 0.3
Silt, Colorado - BRCO									
Garfield County Regional Airport 03016 (39.53, -107.72)	4.2 miles	Sample Day (62)	62.2 ± 6.0	47.5 ± 5.4	27.3 ± 3.5	37.7 ± 4.0	53.8 ± 4.5	1017.6 ± 2.4	4.8 ± 0.7
	311° (NW)	2013	60.6 ± 2.4	46.8 ± 2.2	27.5 ± 1.5	37.5 ± 1.6	55.3 ± 1.9	1017.8 ± 0.9	4.6 ± 0.3
Parachute, Colorado - PACO									
Garfield County Regional Airport 03016 (39.53, -107.72)	18.6 miles	Sample Day (56)	64.3 ± 6.1	49.0 ± 5.6	27.9 ± 3.6	38.7 ± 4.1	52.5 ± 4.7	1017.8 ± 2.4	4.7 ± 0.7
	74° (ENE)	2013	60.6 ± 2.4	46.8 ± 2.2	27.5 ± 1.5	37.5 ± 1.6	55.3 ± 1.9	1017.8 ± 0.9	4.6 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 8-3. Average Meteorological Conditions near the Colorado Monitoring Sites (Continued)

Closest NWS Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Rifle, Colorado - RICO									
Garfield County Regional Airport 03016 (39.53, -107.72)	3.4 miles	Sample Day (59)	61.7 ± 6.1	46.9 ± 5.5	26.8 ± 3.5	37.2 ± 4.0	53.8 ± 4.7	1017.7 ± 2.4	4.8 ± 0.7
	95° (E)	2013	60.6 ± 2.4	46.8 ± 2.2	27.5 ± 1.5	37.5 ± 1.6	55.3 ± 1.9	1017.8 ± 0.9	4.6 ± 0.3
Carbondale, Colorado - RFCO									
Aspen-Pitkin County Airport 93073 (39.23, -106.87)	23.0 miles	Sample Day (31)	56.6 ± 7.4	41.8 ± 6.8	23.1 ± 5.0	33.3 ± 5.3	54.0 ± 5.3	1017.8 ± 2.9	5.1 ± 0.4
	123° (ESE)	2013	53.2 ± 2.1	39.9 ± 1.9	23.6 ± 1.5	32.6 ± 1.5	59.0 ± 1.8	1016.1 ± 0.8	4.9 ± 0.2

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 8-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 8-3 is the 95 percent confidence interval for each parameter. As shown in Table 8-3, average meteorological conditions on sample days near GPCO were representative of average weather conditions experienced throughout the year. The parameter with the largest difference between the full-year average and the sample day average for GPCO is dew point temperature.

Of the four Garfield County sites for which Garfield County Regional Airport is the closest weather station, BMCO and PACO have the fewest sample days. Both of these sites missed two sample days in January. BMCO also missed a sample day in March. PACO missed two sample days in February and another in December. This may explain why temperatures on sample days appear slightly higher at these sites compared to BRCO and RICO as all of the missed sample dates are during colder months of the year.

RFCO sampled on a 1-in-12 day schedule, yielding roughly half the number of collection events as the other sites; thus, the number of observations included in each calculation for RFCO is roughly half the number for the other Colorado sites. As a result, there is a higher level of variability in the meteorological averages for this site, as indicated by the confidence intervals shown. For RFCO, the temperature parameters on sample days appear higher than those shown for the entire year. In addition, relative humidity levels were lower on sample days than over the entire year, as shown in Table 8-3.

The average temperature shown for RFCO for 2013 is the second lowest average temperature among NMP sites, behind only the Anchorage, Alaska site (ANAK). All six Colorado sites account for the six lowest average dew point temperatures among NMP sites; RFCO also has the lowest average wet bulb temperature. These sites also experienced some of the lowest relative humidity levels among NMP sites.

8.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations at the Walker Field Airport (for GPCO), Garfield County Regional Airport (for BMCO, BRCO, PACO, and RICO), and Pitkin-Aspen County Airport (for RFCO) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 8-10 presents a map showing the distance between the weather station and GPCO, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 8-10 also presents three different wind roses for the GPCO monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind observations for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 8-11 through 8-15 present the distance maps and wind roses for the five Garfield County sites.

Observations from Figure 8-10 for GPCO include the following:

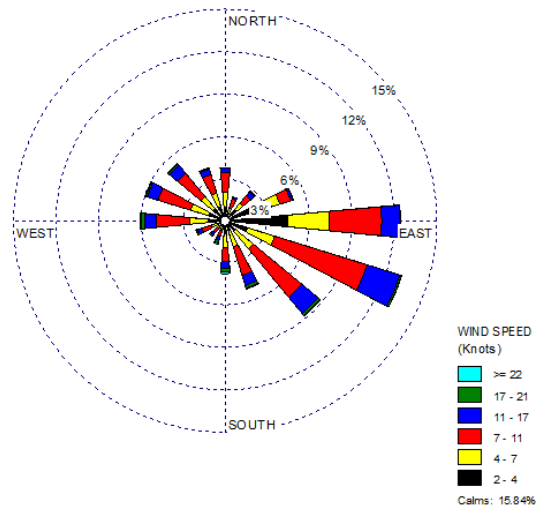
- The Walker Field Airport weather station is located 5 miles north-northeast of GPCO. Most of the city of Grand Junction lies between the site and the airport. The airport property where the weather station is located is adjacent to where the elevation begins to increase on the north side of the city.
- The historical wind rose shows that easterly and east-southeasterly winds were prevalent near GPCO over the last 10 years. Winds from the east-northeast to south-southeast account for nearly half of the wind observations near GPCO. Winds from the west to northwest make up a secondary wind grouping. Winds from the southwest quadrant and north-northeast to northeast directions were rarely observed. Calm winds (those less than or equal to 2 knots) were observed for approximately 16 percent of the hourly wind measurements.
- The 2013 wind rose exhibits similar wind patterns as the historical wind rose. The sample day wind patterns also resemble the historical and full-year wind patterns, indicating that wind conditions on sample days were representative of those experienced over the entire year and historically.

Figure 8-10. Wind Roses for the Grand Junction Regional Airport Weather Station near GPCO

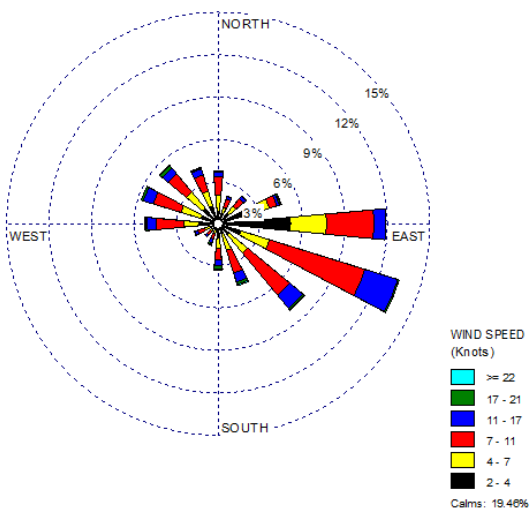
Location of GPCO and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

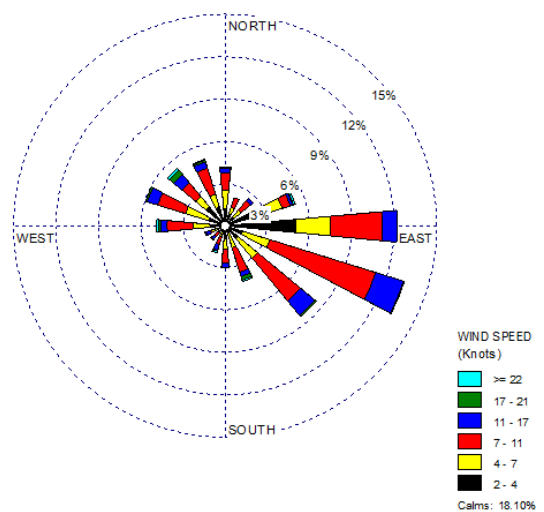
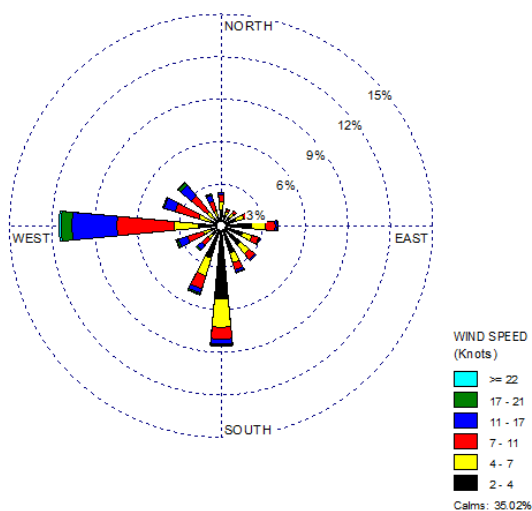


Figure 8-11. Wind Roses for the Garfield County Regional Airport Weather Station near BMCO

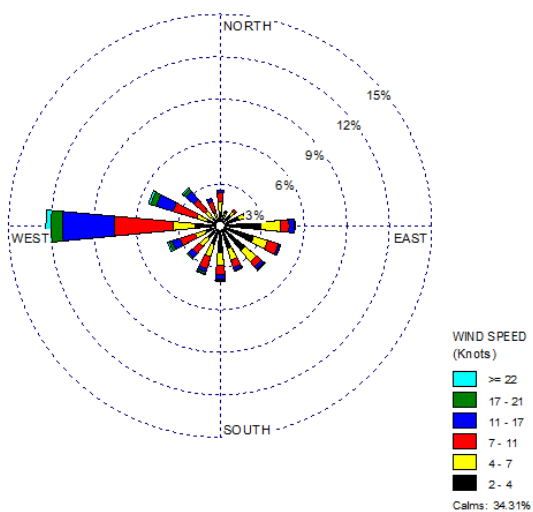
Location of BMCO and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

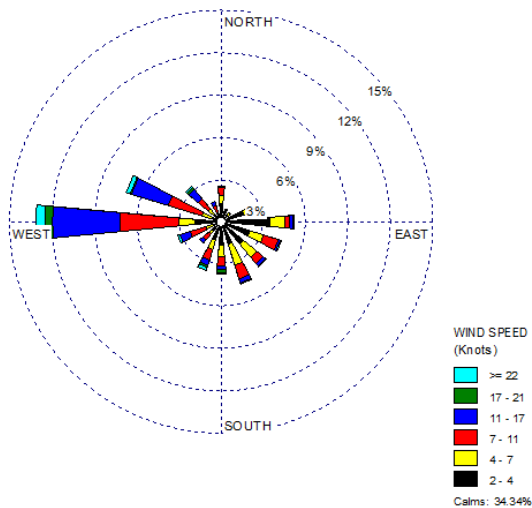
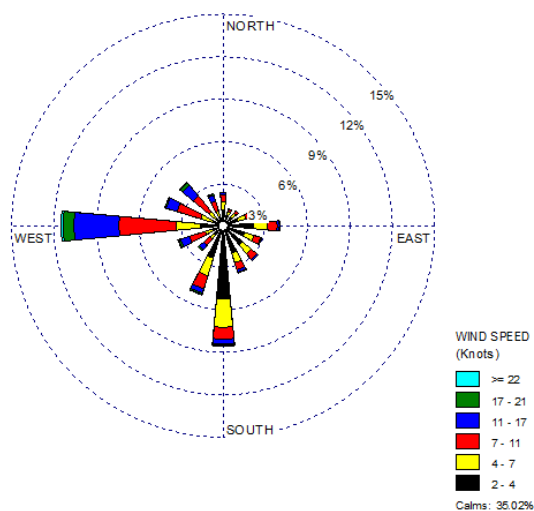


Figure 8-12. Wind Roses for the Garfield County Regional Airport Weather Station near BRCO

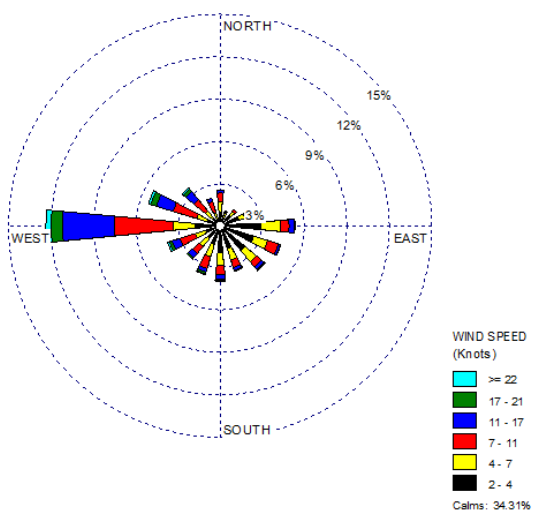
Location of BRCO and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

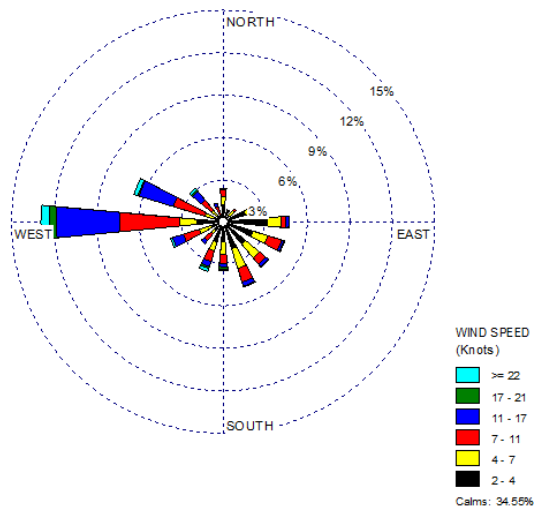
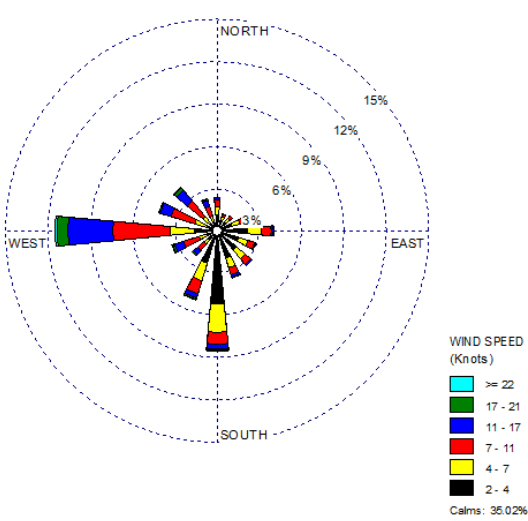


Figure 8-13. Wind Roses for the Garfield County Regional Airport Weather Station near PACO

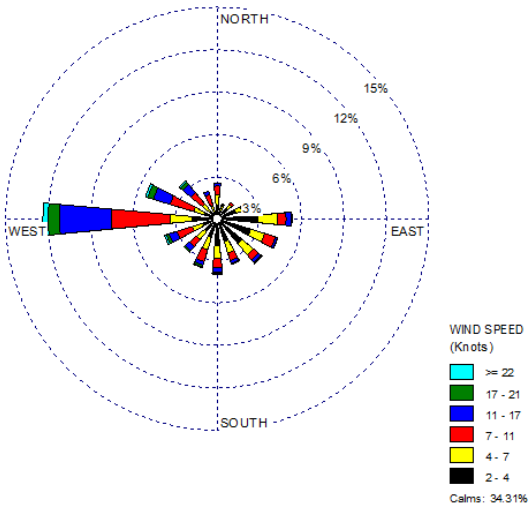
Location of PACO and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

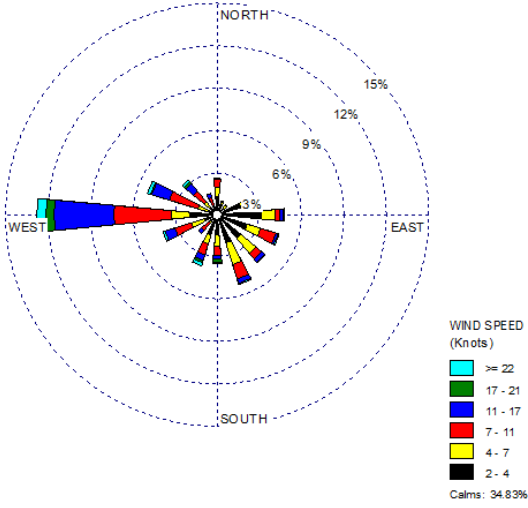
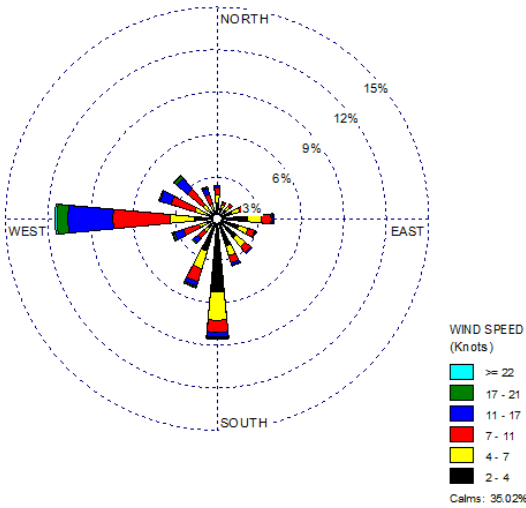


Figure 8-14. Wind Roses for the Garfield County Regional Airport Weather Station near RICO

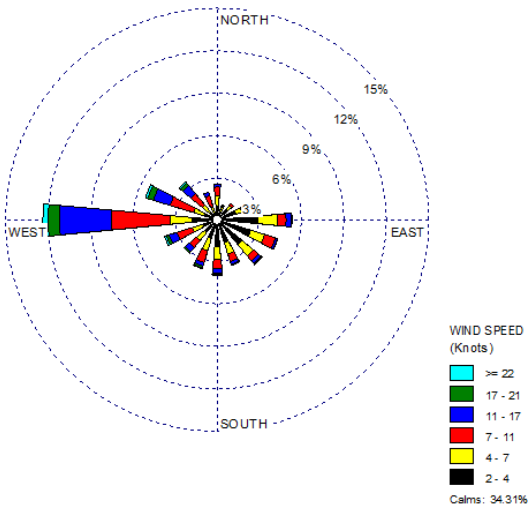
Location of RICO and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

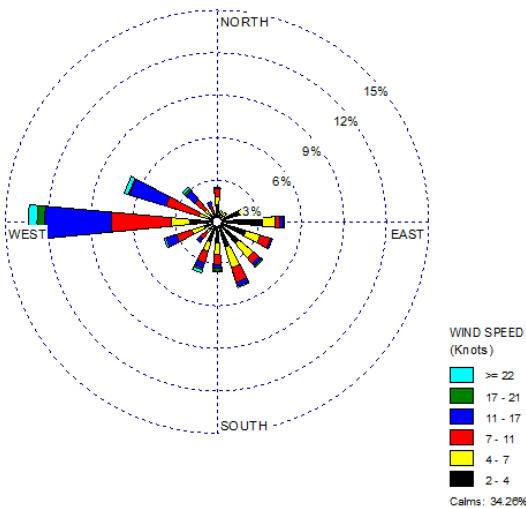
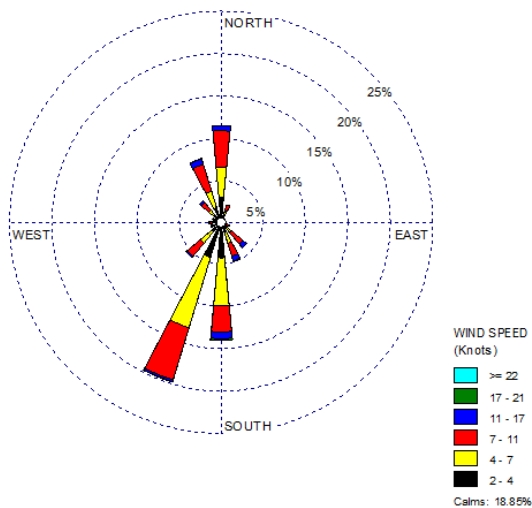


Figure 8-15. Wind Roses for the Aspen-Pitkin County Airport Weather Station near RFCO

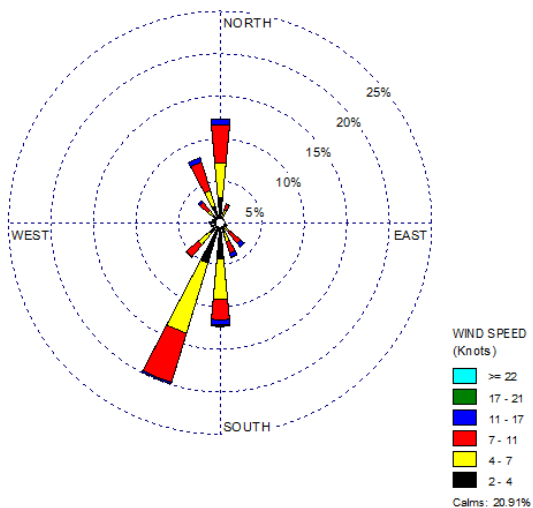
Location of RFCO and Weather Station



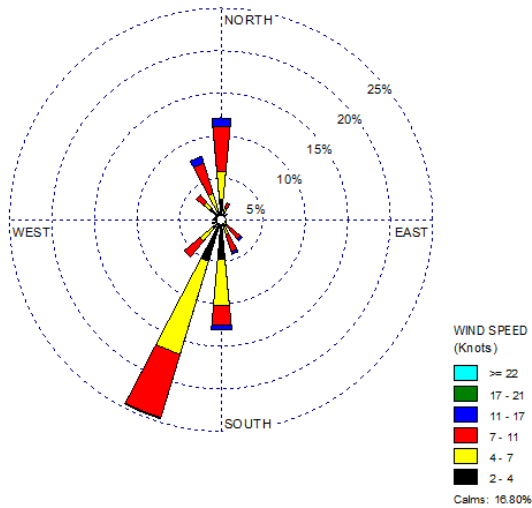
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figures 8-11 through 8-14 for BMCO, BRCO, PACO, and RICO, respectively, include the following:

- The weather station at Garfield County Regional Airport is the closest weather station to four of the five monitoring sites in Garfield County. The weather station is located east of Rifle, just south of I-70. The distance from the weather station to the sites varies from about 3 miles (RICO) to greater than 18 miles (PACO).
- The historical and 2013 wind roses for these Garfield County sites are identical to each other because the wind observations come from the same weather station for all four sites.
- The historical wind roses show that calm winds were prevalent near the monitoring sites, representing more than one-third of wind observations. For wind speeds greater than 2 knots, westerly winds were prevalent, followed by southerly and south-southwesterly winds. Winds from the northeast quadrant were rarely observed.
- Calm winds were observed for 34 percent of the wind observations in 2013. Westerly winds were again prevalent in 2013, although fewer southerly and south-southwesterly winds were observed in 2013 near the Garfield County sites compared to the historical wind rose. A similar observation was made in the 2011 and 2012 NMP reports.
- The sample day wind patterns for each site resemble the full-year wind patterns, indicating that conditions on sample days were representative of those experienced over the entire year. With the exception of PACO, each Garfield County site's sample day wind rose shows that a slightly higher number of west-northwesterly winds were observed on sample days compared to all of 2013.

Observations from Figure 8-15 for RFCO include the following:

- The Aspen-Pitkin County Airport weather station is located 23 miles east-southeast of RFCO. The mountainous terrain surrounding the site and weather station is visible in Figure 8-15.
- The historical wind rose shows that winds from the south and south-southwest are prevalent near RFCO, accounting for one-third of the wind observations from this weather station. Winds from the north-northwest and north make up roughly 20 percent of wind observations. Calm winds account for just less than one-fifth of observations. Winds from the north-northeast to east-southeast and west-southwest to northwest were rarely observed. The wind flow tends to follow the orientation of the valley, similar to the wind observations near the other Garfield County sites.
- The 2013 wind rose exhibits similar wind patterns as the historical wind rose, indicating that conditions in 2013 were similar to conditions experienced over the last 10 years.

- The sample day wind rose has similar wind patterns as the full-year and historical wind roses, but has a higher percentage of south-southwesterly winds, accounting for nearly 25 percent of observations on sample days.

8.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Colorado monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 8-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 8-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. VOCs, carbonyl compounds, PAHs, and hexavalent chromium were sampled for at GPCO while SNMOCs and carbonyl compounds were sampled for at the Garfield County sites.

Table 8-4. Risk-Based Screening Results for the Colorado Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Grand Junction, Colorado - GPCO						
Benzene	0.13	61	61	100.00	12.82	12.82
Carbon Tetrachloride	0.17	60	60	100.00	12.61	25.42
1,3-Butadiene	0.03	59	61	96.72	12.39	37.82
Acetaldehyde	0.45	58	58	100.00	12.18	50.00
Formaldehyde	0.077	58	58	100.00	12.18	62.18
Naphthalene	0.029	54	56	96.43	11.34	73.53
1,2-Dichloroethane	0.038	45	45	100.00	9.45	82.98
Ethylbenzene	0.4	32	61	52.46	6.72	89.71
Acenaphthene	0.011	14	56	25.00	2.94	92.65
Hexachloro-1,3-butadiene	0.045	11	13	84.62	2.31	94.96
Benzo(a)pyrene	0.00057	8	37	21.62	1.68	96.64
Fluorene	0.011	8	54	14.81	1.68	98.32
Acenaphthylene	0.011	3	36	8.33	0.63	98.95
Propionaldehyde	0.8	3	58	5.17	0.63	99.58
Dichloromethane	60	2	61	3.28	0.42	100.00
Total		476	775	61.42		
Battlement Mesa, Colorado - BMCO						
Benzene	0.13	54	54	100.00	55.67	55.67
Formaldehyde	0.077	26	28	92.86	26.80	82.47
Acetaldehyde	0.45	11	27	40.74	11.34	93.81
1,3-Butadiene	0.03	3	3	100.00	3.09	96.91
Ethylbenzene	0.4	3	50	6.00	3.09	100.00
Total		97	162	59.88		
Silt, Colorado - BRCO						
Benzene	0.13	57	57	100.00	55.88	55.88
Formaldehyde	0.077	26	26	100.00	25.49	81.37
Acetaldehyde	0.45	16	26	61.54	15.69	97.06
1,3-Butadiene	0.03	2	2	100.00	1.96	99.02
Ethylbenzene	0.4	1	48	2.08	0.98	100.00
Total		102	159	64.15		
Parachute, Colorado - PACO						
Benzene	0.13	49	49	100.00	45.37	45.37
Formaldehyde	0.077	26	26	100.00	24.07	69.44
Acetaldehyde	0.45	19	25	76.00	17.59	87.04
1,3-Butadiene	0.03	9	9	100.00	8.33	95.37
Ethylbenzene	0.4	5	52	9.62	4.63	100.00
Total		108	161	67.08		

Table 8-4. Risk-Based Screening Results for the Colorado Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Carbondale, Colorado - RFCO						
Formaldehyde	0.077	25	27	92.59	36.23	36.23
Benzene	0.13	23	23	100.00	33.33	69.57
Acetaldehyde	0.45	15	27	55.56	21.74	91.30
1,3-Butadiene	0.03	6	6	100.00	8.70	100.00
Total		69	83	83.13		
Rifle, Colorado - RICO						
Benzene	0.13	57	57	100.00	33.53	33.53
1,3-Butadiene	0.03	52	52	100.00	30.59	64.12
Formaldehyde	0.077	24	25	96.00	14.12	78.24
Acetaldehyde	0.45	19	25	76.00	11.18	89.41
Ethylbenzene	0.4	18	57	31.58	10.59	100.00
Total		170	216	78.70		

Observations from Table 8-4 include the following:

- The number of pollutants failing screens varied significantly between GPCO and the Garfield County monitoring sites; this is expected given the difference in pollutants measured at the sites.
- Fifteen pollutants failed at least one screen for GPCO; 61 percent of the concentrations for these 15 pollutants were greater than their associated risk screening value (or failed screens).
- Twelve pollutants contributed to 95 percent of failed screens for GPCO and therefore were identified as pollutants of interest for GPCO. These 12 include two carbonyl compounds, six VOCs, and four PAHs. Although the 95 percent criteria is met with benzo(a)pyrene, fluorene is also considered a pollutant of interest because it failed the same number of screens as benzo(a)pyrene, per the steps described in Section 3.2.
- The number of pollutants failing screens for the Garfield County sites range from four (RFCO) to five (the remaining sites). The same four pollutants (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) failed screens for each Garfield County site. Ethylbenzene also failed screens for all sites except RFCO.
- Benzene, formaldehyde, and acetaldehyde were identified as pollutants of interest for all five Garfield County sites. 1,3-Butadiene was also identified as a pollutant of interest for all five sites except BRCO, and ethylbenzene was also identified as a pollutant of interest for BMCO and RICO.
- Benzene failed 100 percent of screens for all six Colorado sites.

- Note that carbonyl compound samples were collected on a 1-in-12 day sampling schedule at BMCO, BRCO, PACO, and RICO, while SNMOC samples were collected on a 1-in-6 day sampling schedule; thus, the number of carbonyl compound samples collected at these sites were often less than half the number of SNMOC samples. Both carbonyl compound and SNMOC samples were collected on a 1-in-12 day sampling schedule at RFCO.

8.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Colorado monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled at the Colorado monitoring sites are provided in Appendices J through M and O.

8.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Colorado monitoring site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Colorado monitoring sites are presented in Table 8-5, where applicable. Note that concentrations

of the PAHs for GPCO are presented in ng/m³ for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 8-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Colorado Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
Grand Junction, Colorado - GPCO						
Acetaldehyde	58/58	3.88 ± 0.69	5.78 ± 1.40	2.56 ± 0.99	2.86 ± 0.56	3.79 ± 0.57
Benzene	61/61	1.35 ± 0.38	0.59 ± 0.07	0.59 ± 0.10	1.42 ± 0.32	0.99 ± 0.16
1,3-Butadiene	61/61	0.18 ± 0.06	0.07 ± 0.02	0.08 ± 0.02	0.26 ± 0.06	0.15 ± 0.03
Carbon Tetrachloride	60/61	0.52 ± 0.10	0.61 ± 0.04	0.65 ± 0.03	0.56 ± 0.03	0.59 ± 0.03
1,2-Dichloroethane	45/61	0.07 ± 0.02	0.08 ± 0.02	0.05 ± 0.02	0.07 ± 0.02	0.07 ± 0.01
Ethylbenzene	61/61	0.52 ± 0.16	0.33 ± 0.06	0.41 ± 0.13	0.67 ± 0.13	0.49 ± 0.07
Formaldehyde	58/58	5.30 ± 0.61	11.77 ± 2.85	4.70 ± 2.14	3.72 ± 0.66	6.44 ± 1.22
Hexachloro-1,3-butadiene	13/61	0.03 ± 0.03	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.02	0.02 ± 0.01
Acenaphthene ^a	56/56	4.07 ± 1.41	9.99 ± 3.98	13.85 ± 3.89	4.30 ± 1.53	8.05 ± 1.77
Benzo(a)pyrene ^a	37/56	0.44 ± 0.28	0.02 ± 0.01	0.01 ± 0.01	0.47 ± 0.20	0.24 ± 0.10
Fluorene ^a	54/56	4.72 ± 1.42	7.49 ± 2.69	9.70 ± 2.52	5.63 ± 1.22	6.88 ± 1.09
Naphthalene ^a	56/56	162.62 ± 68.12	100.86 ± 30.39	108.54 ± 26.77	175.72 ± 45.42	136.93 ± 23.05
Battlement Mesa, Colorado - BMCO						
Acetaldehyde	27/28	0.41 ± 0.23	0.50 ± 0.18	0.54 ± 0.36	0.37 ± 0.22	0.46 ± 0.11
Benzene	54/55	NA	1.00 ± 0.10	0.98 ± 0.13	1.74 ± 0.57	1.26 ± 0.19
1,3-Butadiene	3/55	NA	0	0	0.01 ± 0.02	<0.01 ± <0.01
Ethylbenzene	50/55	NA	0.10 ± 0.02	0.07 ± 0.02	0.21 ± 0.08	0.14 ± 0.03
Formaldehyde	28/28	0.64 ± 0.29	0.83 ± 0.09	1.20 ± 0.88	0.56 ± 0.27	0.82 ± 0.23

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

^a Average concentrations provided for the pollutants below the blue line for GPCO are presented in ng/m³ for ease of viewing.

Table 8-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Colorado Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Silt, Colorado - BRCO						
Acetaldehyde	26/26	0.52 ± 0.23	0.62 ± 0.18	0.70 ± 0.45	0.39 ± 0.16	0.56 ± 0.12
Benzene	57/57	1.50 ± 0.51	NA	0.82 ± 0.12	1.23 ± 0.47	1.14 ± 0.20
Formaldehyde	26/26	0.75 ± 0.34	0.87 ± 0.18	1.28 ± 0.62	0.62 ± 0.27	0.87 ± 0.18
Parachute, Colorado - PACO						
Acetaldehyde	25/26	0.86 ± 0.49	0.87 ± 0.24	NA	0.53 ± 0.35	0.76 ± 0.18
Benzene	49/52	NA	1.19 ± 0.28	1.62 ± 0.46	2.56 ± 0.60	1.96 ± 0.31
1,3-Butadiene	9/52	NA	<0.01 ± 0.01	0	0.03 ± 0.03	0.01 ± 0.01
Formaldehyde	26/26	1.35 ± 0.67	1.38 ± 0.13	1.28 ± 0.69	1.08 ± 0.69	1.28 ± 0.25
Carbondale, Colorado - RFCO						
Acetaldehyde	27/27	0.61 ± 0.43	0.88 ± 0.42	0.60 ± 0.53	0.28 ± 0.16	0.58 ± 0.19
Benzene	23/29	0.75 ± 0.30	0.40 ± 0.10	NA	0.55 ± 0.24	0.57 ± 0.12
1,3-Butadiene	6/29	0.04 ± 0.04	0.01 ± 0.01	0.01 ± 0.03	0.02 ± 0.04	0.02 ± 0.01
Formaldehyde	27/27	0.79 ± 0.55	0.98 ± 0.36	0.98 ± 0.59	0.35 ± 0.20	0.75 ± 0.21
Rifle, Colorado - RICO						
Acetaldehyde	25/25	1.16 ± 0.60	1.07 ± 0.16	0.96 ± 0.50	0.56 ± 0.45	NA
Benzene	57/57	2.07 ± 0.55	1.00 ± 0.12	0.96 ± 0.11	2.11 ± 0.70	1.52 ± 0.26
1,3-Butadiene	52/57	0.14 ± 0.04	0.06 ± 0.01	0.07 ± 0.03	0.18 ± 0.05	0.11 ± 0.02
Ethylbenzene	57/57	0.38 ± 0.08	0.29 ± 0.05	0.29 ± 0.04	0.45 ± 0.13	0.35 ± 0.04
Formaldehyde	25/25	1.56 ± 0.67	1.19 ± 0.16	2.00 ± 1.12	0.87 ± 0.82	NA

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

^a Average concentrations provided for the pollutants below the blue line for GPCO are presented in ng/m^3 for ease of viewing.

Observations for GPCO from Table 8-5 include the following:

- The pollutants with the highest annual average concentrations for GPCO are formaldehyde ($6.44 \pm 1.22 \mu\text{g}/\text{m}^3$) and acetaldehyde ($3.79 \pm 0.57 \mu\text{g}/\text{m}^3$). These are also the only pollutants with annual average concentrations greater than $1 \mu\text{g}/\text{m}^3$, although benzene is very close ($0.99 \pm 0.16 \mu\text{g}/\text{m}^3$). The annual average

concentrations for these carbonyl compounds are considerably higher for 2013 than they were for 2012.

- The second quarter average concentrations for both acetaldehyde and formaldehyde are considerably higher than the other quarterly averages and have relatively large confidence intervals associated with them, particularly for formaldehyde. A review of the data shows that all but one of the 13 formaldehyde concentrations greater than $7.50 \mu\text{g}/\text{m}^3$ were measured at GPCO during the second quarter of 2013 (with the exception being measured on the first sample day in the third quarter). These measurements range from $7.74 \mu\text{g}/\text{m}^3$ to $21.9 \mu\text{g}/\text{m}^3$. The five highest concentrations of formaldehyde measured across the program were all measured at GPCO (between June 3, 2013 and July 3, 2013). Similar observations can be made for acetaldehyde concentrations measured at GPCO. All but one of the six acetaldehyde concentrations greater than $7.00 \mu\text{g}/\text{m}^3$ were measured at GPCO during the second quarter of 2013 (with the exception being measured on the first sample day in the third quarter). These measurements range from $7.00 \mu\text{g}/\text{m}^3$ to $10.7 \mu\text{g}/\text{m}^3$. Although the maximum acetaldehyde concentration measured across the program was not measured at GPCO, concentrations of acetaldehyde measured at GPCO account for the next five highest acetaldehyde concentrations (and were measured in samples collected between June 9, 2013 and July 3, 2013).
- Concentrations of benzene and 1,3-butadiene appear highest during the colder months of the year, based on the quarterly averages shown in Table 8-5. A review of the data shows that all 18 of GPCO's benzene concentrations greater than $1 \mu\text{g}/\text{m}^3$ were measured during the first or fourth quarters of 2013. Conversely, all nine benzene concentrations less than $0.5 \mu\text{g}/\text{m}^3$ were measured during the second or third quarters of 2013. Similarly, all 16 of GPCO's 1,3-butadiene concentrations greater than $0.2 \mu\text{g}/\text{m}^3$ were measured during the first or fourth quarters of 2013. Other pollutants of interest for GPCO exhibiting a similar tendency include ethylbenzene.
- Of the PAH pollutants of interest, naphthalene has the highest annual average concentration while benzo(a)pyrene has the lowest.
- Concentrations of acenaphthene appear considerably higher during the warmer months of the year, based on the quarterly averages shown in Table 8-5. A review of the data shows that the nine highest concentrations of acenaphthene (those greater than $15 \text{ ng}/\text{m}^3$) were measured between June and August. A similar tendency is shown for fluorene. The four highest concentrations of each of these pollutants were measured on the same days in June and July.
- Conversely, concentrations of benzo(a)pyrene appear higher during the colder months of the year. A review of the data shows that all 15 concentrations of benzo(a)pyrene greater than $0.3 \text{ ng}/\text{m}^3$ were measured at GPCO during the first or fourth quarters of the year, including the five measurements greater than $1 \text{ ng}/\text{m}^3$. Conversely, all but one of GPCO's 19 non-detects were measured during the second or third quarters of 2013.

- The maximum benzo(a)pyrene concentration measured at GPCO (1.49 ng/m³) is the second highest benzo(a)pyrene concentration measured across the program. Further, this site has the highest number of benzo(a)pyrene concentrations greater than 1 ng/m³ (five); no other NMP site sampling PAHs has more than one.
- Although naphthalene concentrations also appear to be highest during the colder months of the year at GPCO, the confidence intervals also indicate that there is considerable variability in these measurements. A review of the naphthalene data shows that concentrations measured at GPCO range from 27.2 ng/m³ to 368 ng/m³, with a median concentration of 100 ng/m³. GPCO is one of only five NMP sites to measure a naphthalene concentration greater than 350 ng/m³ and is one of only two NMP sites to measure more than one of these higher concentrations (NBIL is the other). All of GPCO's naphthalene concentrations greater than 250 ng/m³ were measured during the first or fourth quarters of 2013. However, three of the four lowest naphthalene concentrations measured at GPCO were also measured during the first or fourth quarters of 2013.

Observations for the Garfield County sites from Table 8-5 include the following:

- Acetaldehyde, benzene, and formaldehyde are pollutants of interest for each Garfield County site. However, annual average concentrations of the carbonyl compounds could not be calculated for RICO because the completeness for this method at this site is less than 85 percent, as discussed in Section 2.4.
- With the exception of RFCO, benzene has the highest annual average concentration among the pollutants of interest for the Garfield County sites. Among the Garfield County sites, annual average concentrations of benzene range from 0.57 ± 0.12 µg/m³ (RFCO) to 1.93 ± 0.32 µg/m³ (PACO).
- RICO is the only Garfield County site for which four quarterly average concentrations of benzene are available in Table 8-5. The quarterly average concentrations for RICO show that benzene concentrations tended to be higher during the colder months of the year, similar to the findings for GPCO.
- Among the Garfield County sites, annual average concentrations of formaldehyde range from 0.75 ± 0.21 µg/m³ (RFCO) to 1.28 ± 0.25 µg/m³ (PACO), where they could be calculated. The Garfield County sites' annual averages of formaldehyde are lower than the annual average for GPCO. Further, these sites' annual average formaldehyde concentrations are among the lowest for NMP sites sampling carbonyl compounds, as shown in Figure 4-10 in Section 4. BMCO, BRCO, and RFCO are the only sites, in addition to SEWA, with annual average concentrations of formaldehyde less than 1 µg/m³. Similar observations can be made for acetaldehyde for the Garfield County sites.
- 1,3-Butadiene was identified as a pollutant of interest for all of the Garfield County sites except BMCO, although the detection rate of this pollutant varied significantly. 1,3-Butadiene was detected in 5 percent of samples collected at BMCO, 17 percent at PACO, 21 percent at RFCO, and 91 percent at RICO, which is the closest to GPCO's

100 percent detection rate. The annual average 1,3-butadiene concentrations for GPCO and PACO are similar to each other. Quarterly average concentrations of 1,3-butadiene for RICO exhibit a similar seasonal tendency as GPCO's quarterly averages of 1,3-butadiene. Note that GPCO samples were analyzed with Method TO-15 while PACO's samples were analyzed with the SNMOC method.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Colorado sites from those tables include the following:

- Annual average concentrations for the Colorado sites appear in Tables 4-9 through 4-12 a total of 10 times, with GPCO having the most (6).
- PACO has the highest annual average concentration of benzene among all NMP sites sampling this pollutant. All of the Garfield County sites rank in the top 10 for benzene in Table 4-9, with the exception of RFCO, which ranks 28th. None of the Garfield County sites appear in Table 4-9 for any of the other pollutants listed.
- GPCO's annual average concentrations of acetaldehyde and formaldehyde both rank second highest among NMP sites sampling carbonyl compounds, as shown in Table 4-10. Note that the confidence intervals calculated for the annual averages for GPCO for both pollutants are the highest of those shown in Table 4-10.
- GPCO has the second highest annual concentration of naphthalene and the fourth highest annual concentration of acenaphthene among all NMP sites sampling PAHs, as shown in Table 4-11. GPCO had the highest annual average concentration of naphthalene in the 2010, 2011, and 2012 NMP reports.

8.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for each of the pollutants shaded in gray in Table 8-4 for each site. Note that the box plots for benzene, 1,3-butadiene, and ethylbenzene were split into separate figures, one for measurements sampled with Method TO-15 (GPCO) and one for measurements sampled with the SNMOC method (the Garfield County sites), where annual averages could be calculated. Figures 8-16 through 8-27 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 8-16. Program vs. Site-Specific Average Acenaphthene Concentration

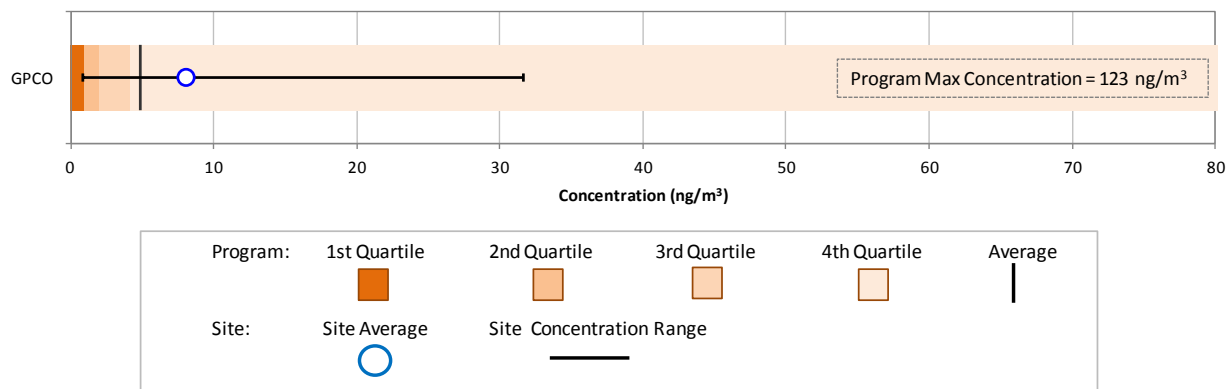


Figure 8-17. Program vs. Site-Specific Average Acetaldehyde Concentrations

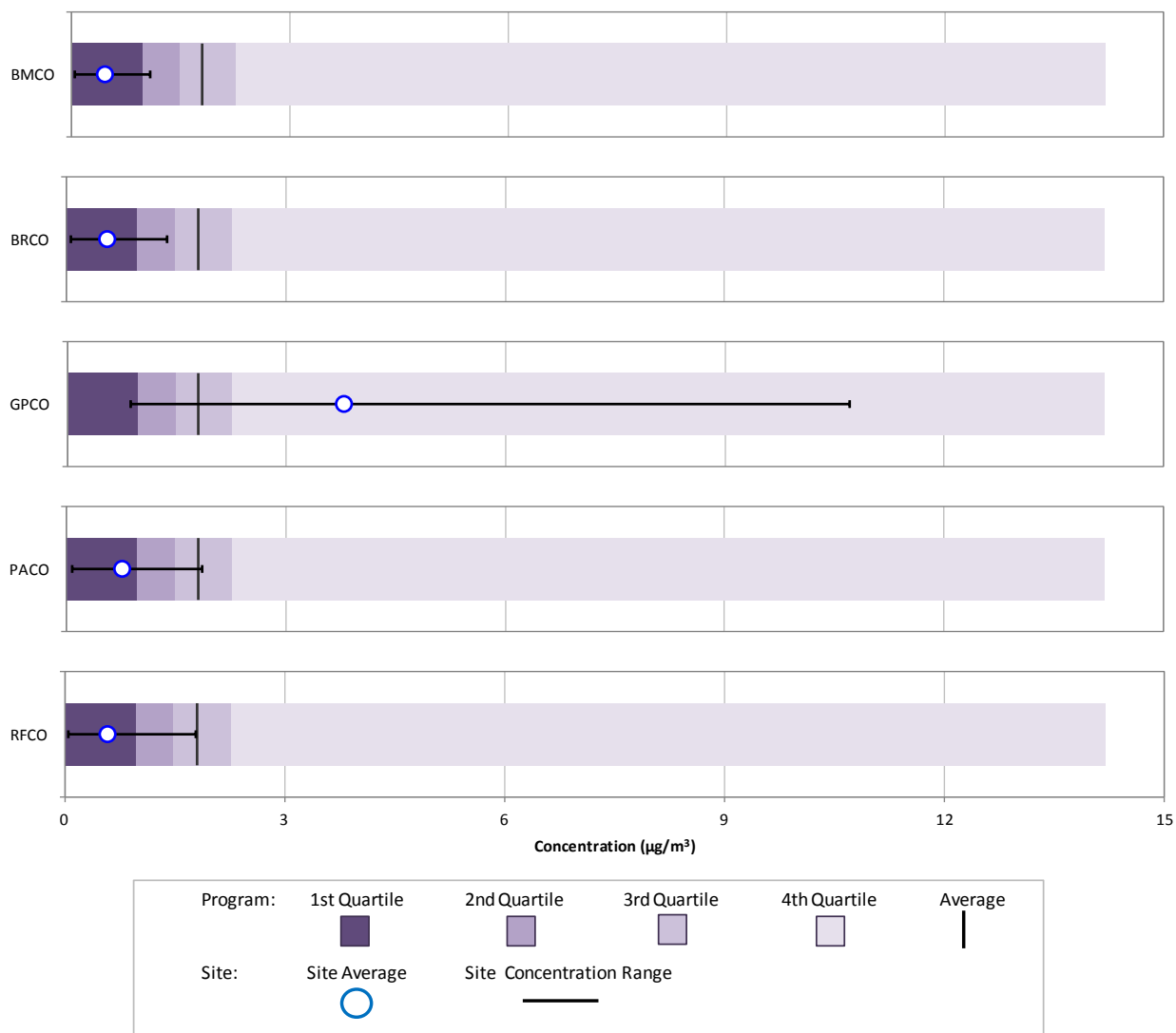


Figure 8-18a. Program vs. Site-Specific Average Benzene (Method TO-15) Concentration

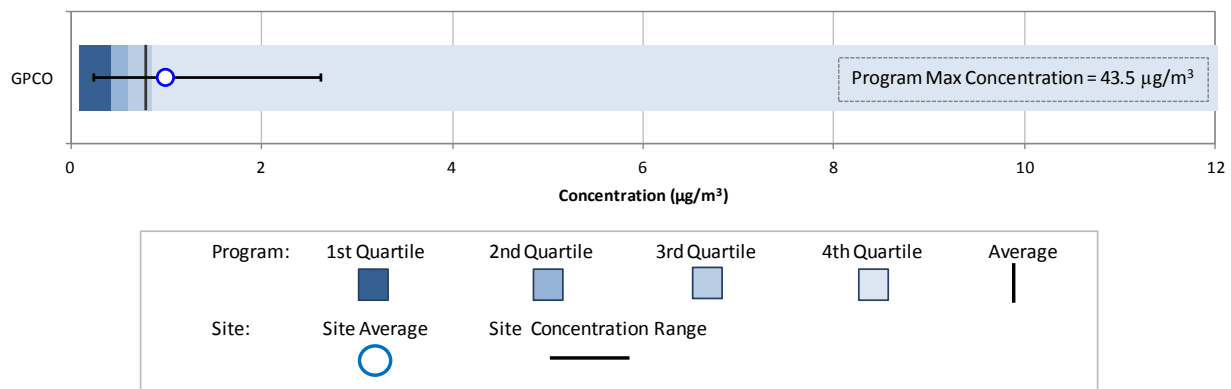


Figure 8-18b. Program vs. Site-Specific Average Benzene (SNMOC) Concentrations

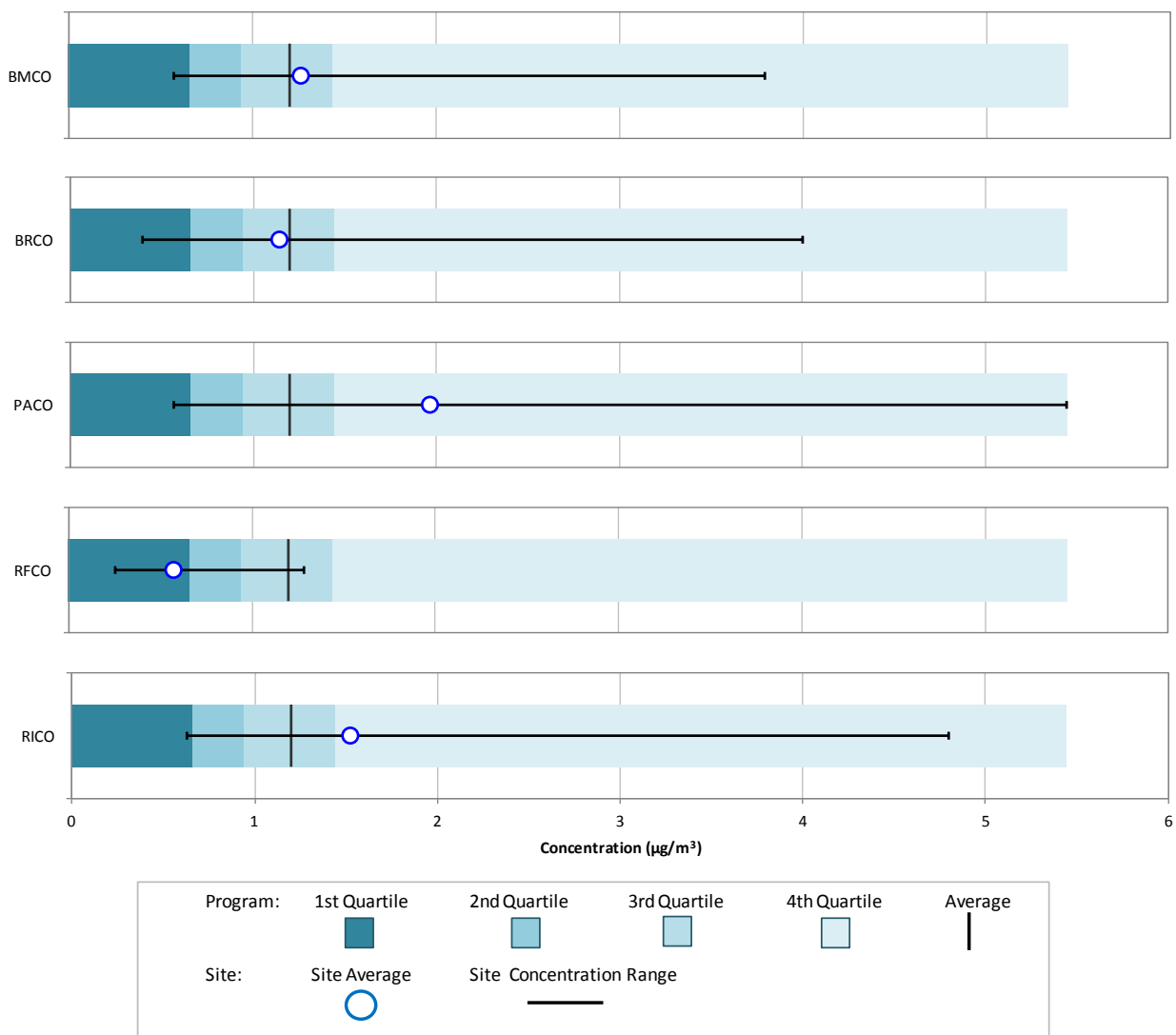


Figure 8-19. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

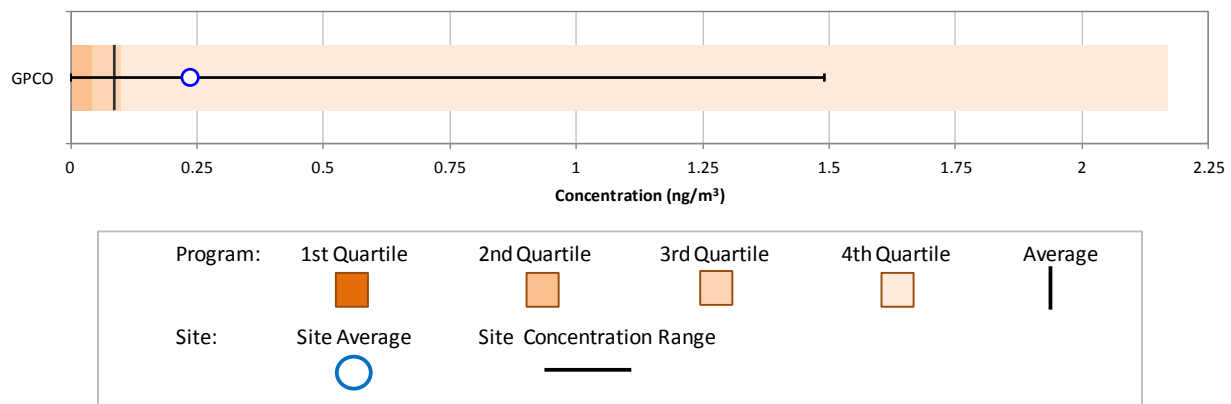


Figure 8-20a. Program vs. Site-Specific Average 1,3-Butadiene (Method TO-15) Concentration

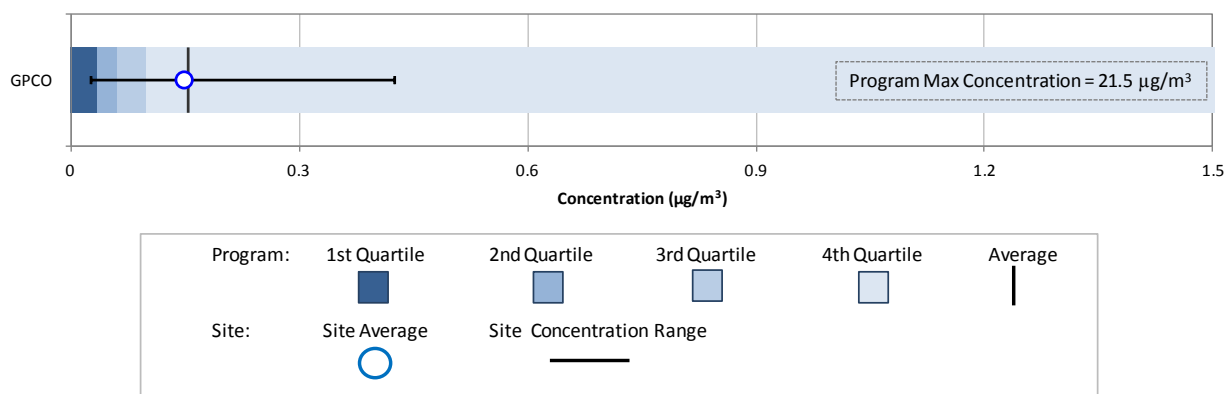


Figure 8-20b. Program vs. Site-Specific Average 1,3-Butadiene (SNMOC) Concentrations

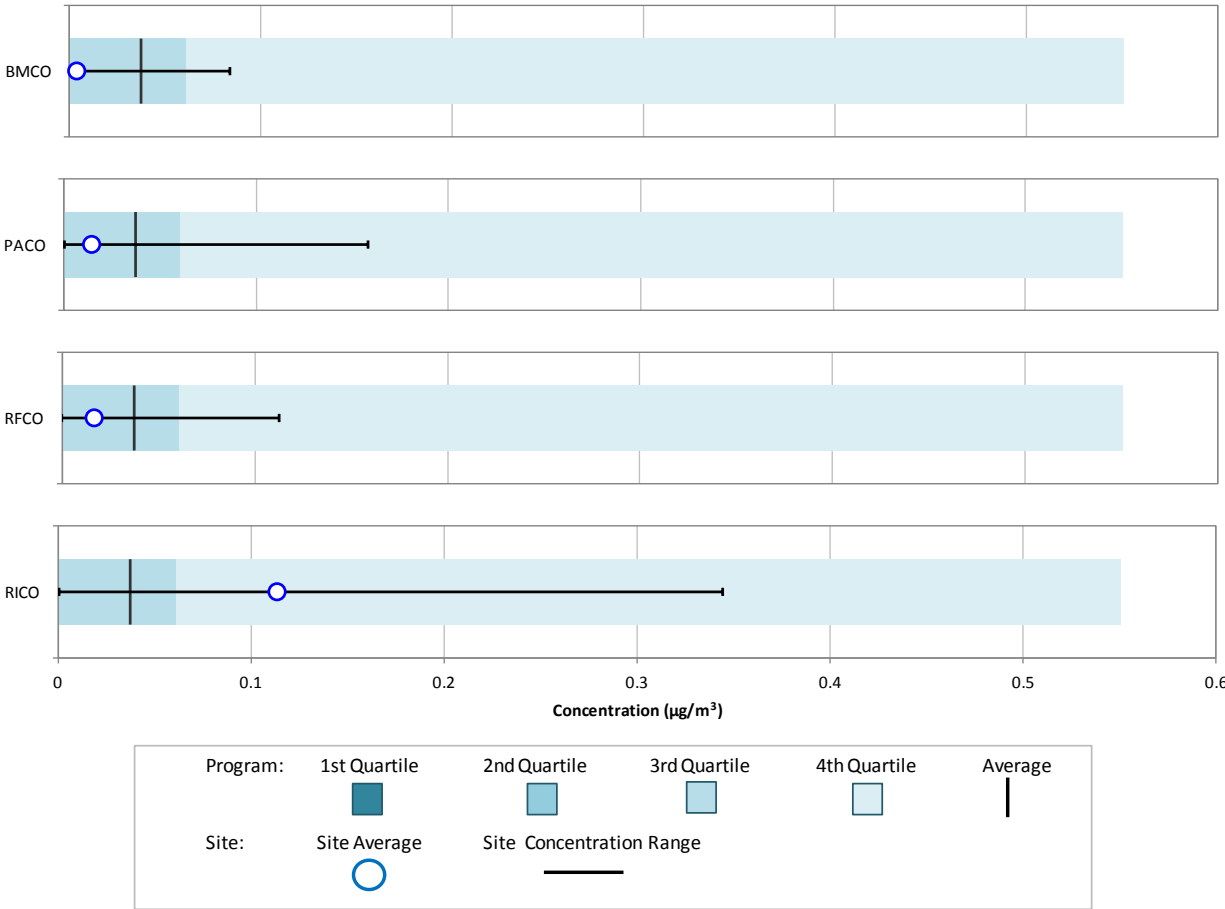


Figure 8-21. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

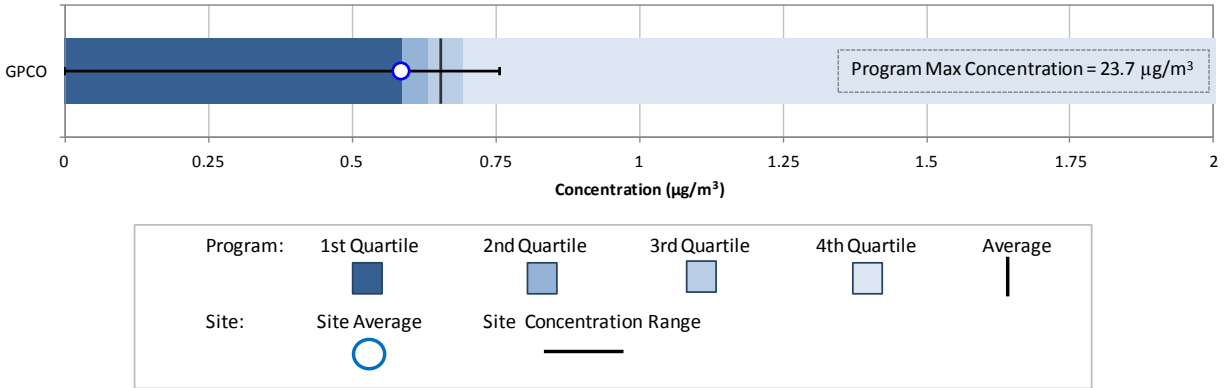


Figure 8-22. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

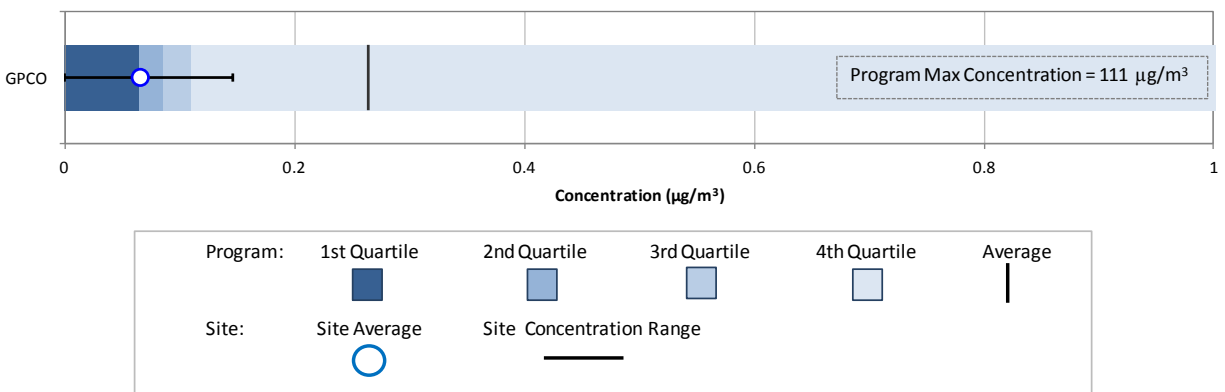


Figure 8-23a. Program vs. Site-Specific Average Ethylbenzene (Method TO-15) Concentration

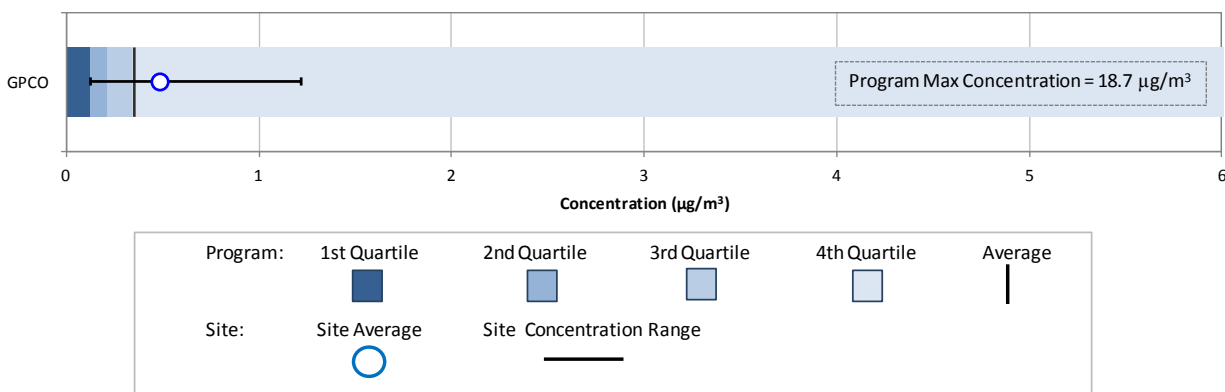


Figure 8-23b. Program vs. Site-Specific Average Ethylbenzene (SNMOC) Concentrations

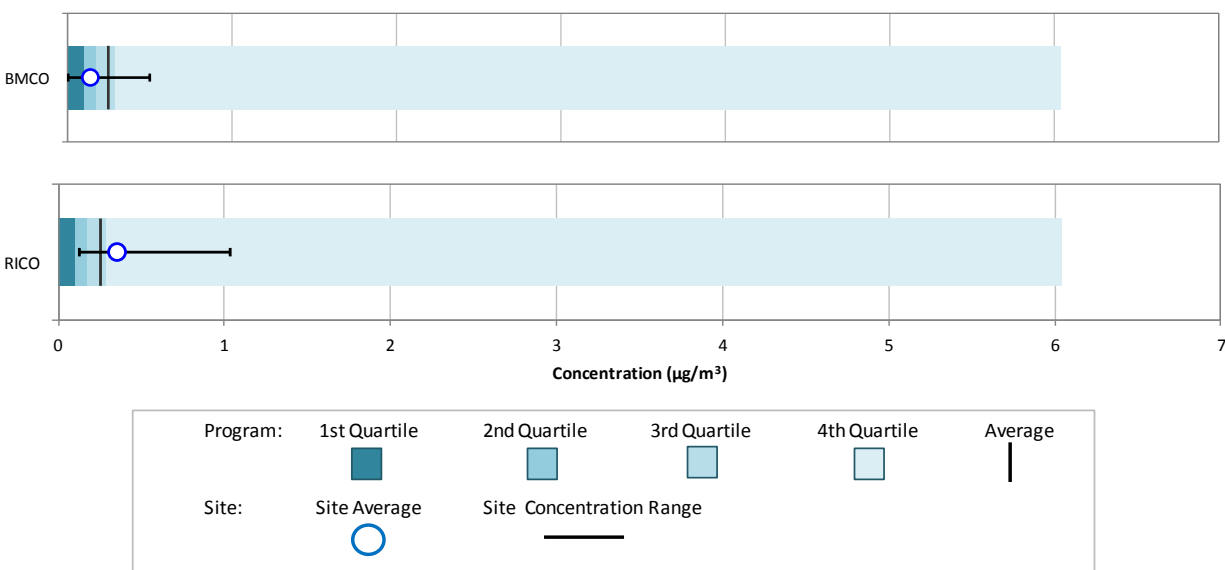


Figure 8-24. Program vs. Site-Specific Average Fluorene Concentration

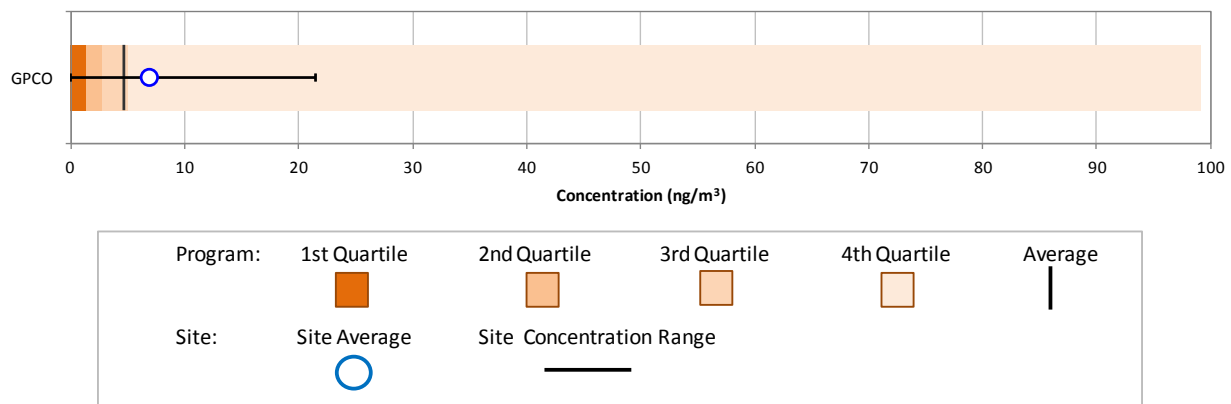


Figure 8-25. Program vs. Site-Specific Average Formaldehyde Concentrations

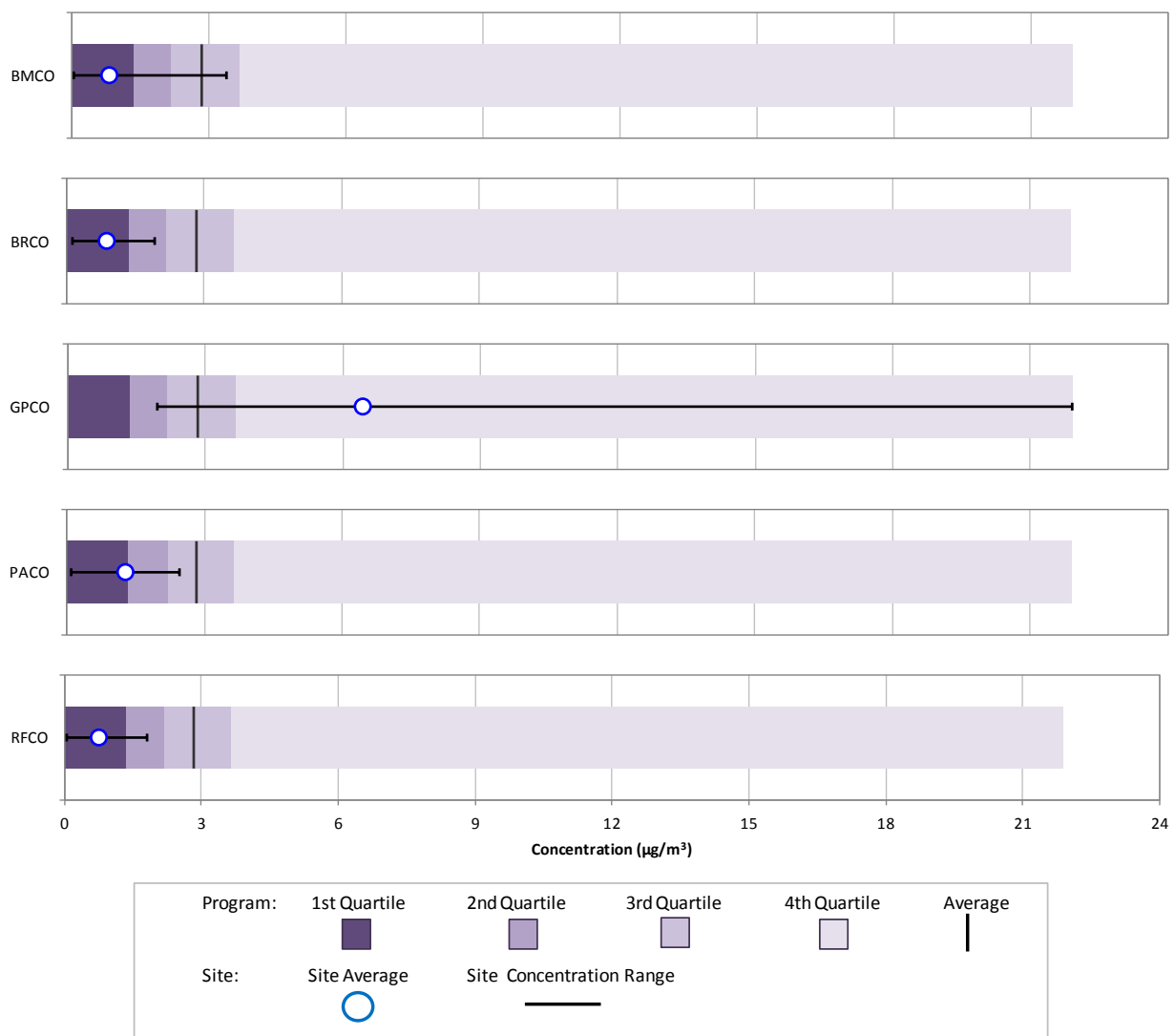


Figure 8-26. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentration

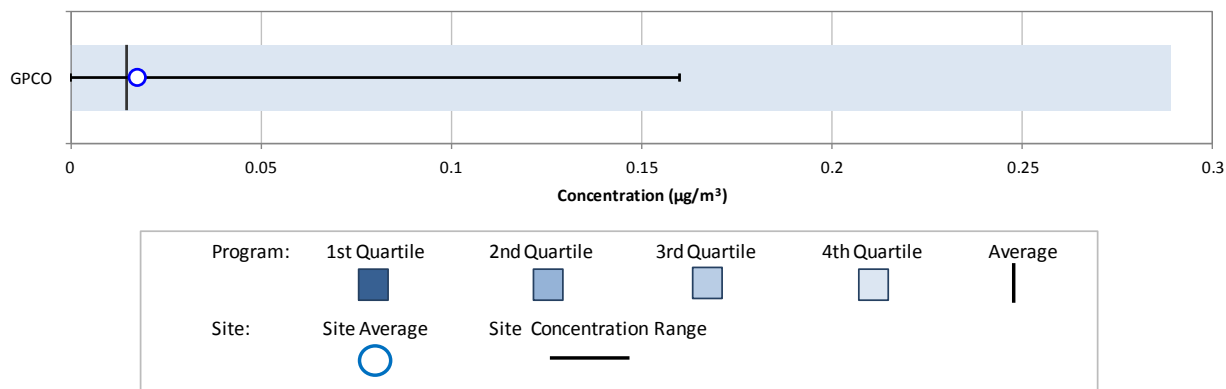
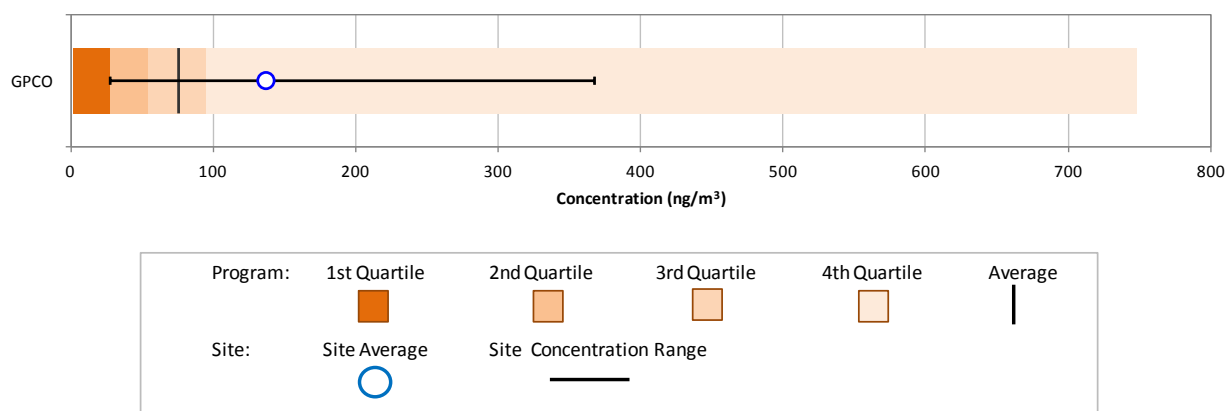


Figure 8-27. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 8-16 through 8-27 include the following:

- Figure 8-16 is the box plot for acenaphthene for GPCO. The program-level maximum concentration ($123 \text{ ng}/\text{m}^3$) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to $80 \text{ ng}/\text{m}^3$. The maximum concentration of acenaphthene measured at GPCO is roughly one-fourth the magnitude of the program-level maximum concentration. However, the annual average acenaphthene concentration for GPCO is greater than the program-level average concentration and is the fourth highest annual average concentration among NMP sites sampling this pollutant.
- Figure 8-17 presents the acetaldehyde box plots for the five Colorado sites for which annual averages could be calculated. The box plots show that the range of acetaldehyde concentrations measured at GPCO is considerably larger than the range of measurements collected at the Garfield County sites. Not surprisingly, GPCO has the highest annual average acetaldehyde concentration among the Colorado sites. The annual average for GPCO is more than five times greater than the next highest annual average acetaldehyde concentration for a Garfield County site (PACO), and is more than twice the program-level average concentration. The minimum acetaldehyde concentration measured at GPCO is greater than the

annual average concentrations for all of the Garfield County sites, an observation that was also made in the 2012 NMP report. The maximum acetaldehyde concentration for each Garfield County site is less than the program-level average, with the exception of PACO.

- Figures 8-18a and 8-18b present the box plots for benzene. Figure 8-18a compares to the benzene concentrations measured at GPCO to those measured across the program for NMP sites sampling VOCs with Method TO-15; Figure 8-18b presents the annual average benzene concentrations for the Garfield County sites compared to the benzene concentrations measured across the program for NMP sites sampling SNMOCs. The box plots are presented this way to correspond with Tables 4-1 and 4-2 in Section 4.1, as discussed in Section 3.4.3.1. Note that the scales are not the same in the figures.
- The program-level maximum concentration ($43.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot in Figure 8-18a because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to $12 \mu\text{g}/\text{m}^3$. Figure 8-18a shows that the annual average benzene concentration for GPCO is slightly higher than the program-level average concentration as well as the third quartile for the program. The maximum benzene concentration measured at GPCO is considerably less than the maximum benzene concentration measured across the program.
- Figure 8-18b includes a box plot for all five Garfield County sites. The maximum benzene concentration measured at PACO is the maximum benzene concentration measured among the seven sites sampling SNMOCs ($5.45 \mu\text{g}/\text{m}^3$). Of the Garfield County sites, PACO has the highest annual average concentration of benzene, followed by RICO then BMCO, BRCO, and RFCO. The range of benzene concentrations measured at RFCO is considerably smaller than the ranges shown for the other Garfield County sites. This sites annual average benzene concentration is less than the program-level first quartile.
- Figure 8-19 is the box plot for benzo(a)pyrene for GPCO. Note that the program-level first quartile is zero and therefore not visible on the box plot. Although the maximum benzo(a)pyrene concentration measured across the program was not measured at GPCO, this site's maximum benzo(a)pyrene concentration is the second highest concentration measured among NMP sites sampling PAHs. The annual average benzo(a)pyrene concentration for GPCO is more than three times the program-level average concentration. Note that GPCO is one of only two NMP sites for which benzo(a)pyrene is a pollutant of interest.
- Similar to the box plots for benzene, Figure 8-20a presents the minimum, maximum, and annual average concentration of 1,3-butadiene for GPCO compared to the 1,3-butadiene concentrations measured across the program for NMP sites sampling VOCs with Method TO-15; Figure 8-20b presents the minimum, maximum, and annual average 1,3-butadiene concentrations for the Garfield County sites compared to the 1,3-butadiene concentrations measured

across the program for NMP sites sampling SNMOCs. Note that the scales are not the same in the figures.

- The program-level maximum concentration ($21.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot in Figure 8-20a as the scale has been reduced to $1.5 \mu\text{g}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. GPCO's annual average 1,3-butadiene concentration is similar to the program-level average concentration. Even though the annual average concentration of 1,3-butadiene for GPCO is among the higher annual averages for this pollutant the maximum 1,3-butadiene concentration measured at GPCO ($0.426 \mu\text{g}/\text{m}^3$) is considerably less than the maximum concentration measured across the program.
- The program-level first and second quartiles are both zero, and thus, not visible in Figure 8-20b, indicating that at least half of the 1,3-butadiene concentrations measured by sites sampling SNMOCs were non-detects. The box plots show that non-detects were measured at each of the Garfield County sites. The maximum 1,3-butadiene concentration measured at RICO ($0.344 \mu\text{g}/\text{m}^3$) is twice the maximum concentration measured among the remaining Garfield County sites. Of the Garfield County sites shown, RICO has the highest annual average concentration of 1,3-butadiene, followed by RFCO, PACO, and BMCO. 1,3-Butadiene is not a pollutant of interest for BRCO.
- The scale of the box plot in Figure 8-21 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum carbon tetrachloride concentration ($23.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Figure 8-21 shows that maximum carbon tetrachloride concentration measured at GPCO is considerably less than the program-level maximum concentration. The annual average carbon tetrachloride concentration for GPCO is less than the program-level median and average concentrations and similar to the program-level first quartile. A single non-detect of carbon tetrachloride was measured at GPCO.
- The scale of the box plot in Figure 8-22 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum 1,2-dichloroethane concentration ($111 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Note that all of the concentrations of 1,2-dichloroethane measured at GPCO are less than the program-level average concentration of $0.26 \mu\text{g}/\text{m}^3$. The annual average concentration for GPCO is similar to the program-level first quartile.
- Similar to the box plots for benzene and 1,3-butadiene, Figure 8-23a presents the minimum, maximum, and annual average concentration of ethylbenzene for GPCO compared to the ethylbenzene concentrations measured across the program for NMP sites sampling VOCs with Method TO-15; Figure 8-23b presents the minimum, maximum, and annual average ethylbenzene concentrations for the Garfield County sites compared to the ethylbenzene concentrations measured

across the program for NMP sites sampling SNMOCs. Note that the scales are not the same in the figures.

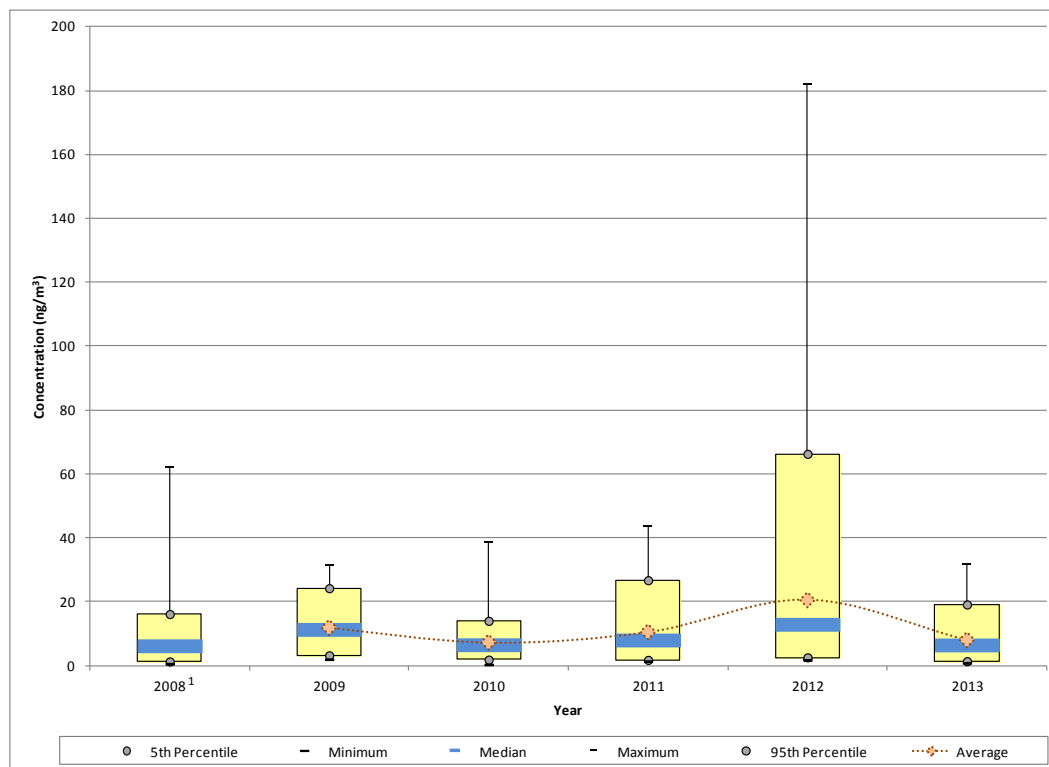
- The scale of the box plot in Figure 8-23a has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum ethylbenzene concentration ($18.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Figure 8-23a for ethylbenzene shows that GPCO's range of ethylbenzene measurements spans approximately $1 \mu\text{g}/\text{m}^3$. GPCO's annual average concentration of ethylbenzene is greater than the program-level average concentration. The minimum ethylbenzene concentration measured at GPCO is similar the program-level first quartile, indicating that roughly 25 percent of the ethylbenzene concentrations across the program are less than GPCO's minimum concentration. Recall from the previous section that GPCO has the sixth highest annual average ethylbenzene concentration among NMP sites sampling ethylbenzene.
- Figure 8-23b presents the box plots for only BMCO and RICO as these are the only Garfield County sites for which ethylbenzene was identified as a pollutant of interest. The range of ethylbenzene concentrations measured at RICO is larger than the range of concentrations measured at BMCO, although both ranges are relatively small compared to the range of concentrations measured by all seven sites sampling SNMOCs. The annual average concentration for RICO is more than twice the annual average concentration for BMCO and the program-level average concentration lies between the two ($0.25 \mu\text{g}/\text{m}^3$).
- Figure 8-24 is the box plot for fluorene for GPCO. The maximum fluorene concentration across the program is considerably higher than the maximum concentration measured at GPCO. Yet, GPCO's annual average concentration is greater than the program-level average concentration and GPCO has the fifth highest annual average concentration among NMP sites sampling PAHs. Two non-detects of fluorene were measured at GPCO.
- Figure 8-25 presents the box plots for formaldehyde for the five Colorado sites for which annual averages could be calculated. These box plots share some of the same characteristics as the box plots for acetaldehyde. The box plot for GPCO shows that the maximum concentration of formaldehyde across the program was measured at this site. GPCO has the highest annual average formaldehyde concentration among the Colorado sites and is the only site for which the annual average concentration is greater than the program-level average concentration. The annual average for GPCO is more than twice the program-level average concentration ($2.83 \mu\text{g}/\text{m}^3$). The minimum formaldehyde concentration measured at GPCO is greater than the program-level first quartile as well as the annual average concentrations for all of the Garfield County sites shown. The maximum formaldehyde concentration measured at each Garfield County site is less than the program-level third quartile and each annual average concentration is less than the program-level first quartile. Similar observations were made in the 2012 NMP report.

- Figure 8-26 is the box plot for hexachloro-1,3-butadiene for GPCO. The program-level first, second (median), and third quartiles are all zero and therefore not visible on the box plot. This is due to the large number of non-detects of this pollutant across the program (82 percent). Sixty-one valid VOC samples were collected at GPCO and of these, hexachloro-1,3-butadiene was detected in only 13 of them. Thus, many zeroes are substituted into the annual average concentration of this pollutant. The maximum hexachloro-1,3-butadiene concentration measured at GPCO is among the higher hexachloro-1,3-butadiene concentrations measured across the program. The annual average concentration for GPCO is just greater than the program-level average concentration of hexachloro-1,3-butadiene.
- Figure 8-27 is the box plot for naphthalene and shows that the maximum concentration of naphthalene across the program is roughly twice the maximum concentration measured at GPCO. The annual average naphthalene concentration for GPCO is greater than the program-level average concentration and the program-level third quartile. Recall from the previous section that GPCO has the second highest annual average naphthalene concentration among NMP sites sampling PAHs. The minimum concentration of naphthalene measured at GPCO is similar to the program-level first quartile.

8.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. GPCO has sampled carbonyl compounds and VOCs under the NMP since 2004 and PAHs since 2008; BRCO, PACO, and RICO began sampling SNMOCs and carbonyl compounds under the NMP in 2008. Thus, Figures 8-28 through 8-49 present the 1-year statistical metrics for each of the pollutants of interest first for GPCO then for BRCO, PACO, and RICO. Note, however, that the 1-year statistical metrics are not provided for the carbonyl compounds for BRCO. This is because sampling was discontinued in October 2010 and did not begin again until September 2011. Thus, 5 consecutive years of data are not available for BRCO for acetaldehyde and formaldehyde. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented. BMCO began sampling SNMOCs and carbonyl compounds under the NMP at the end of 2010 and RFCO began in 2012; thus, the trends analysis was not conducted for these sites.

Figure 8-28. Yearly Statistical Metrics for Acenaphthene Concentrations Measured at GPCO

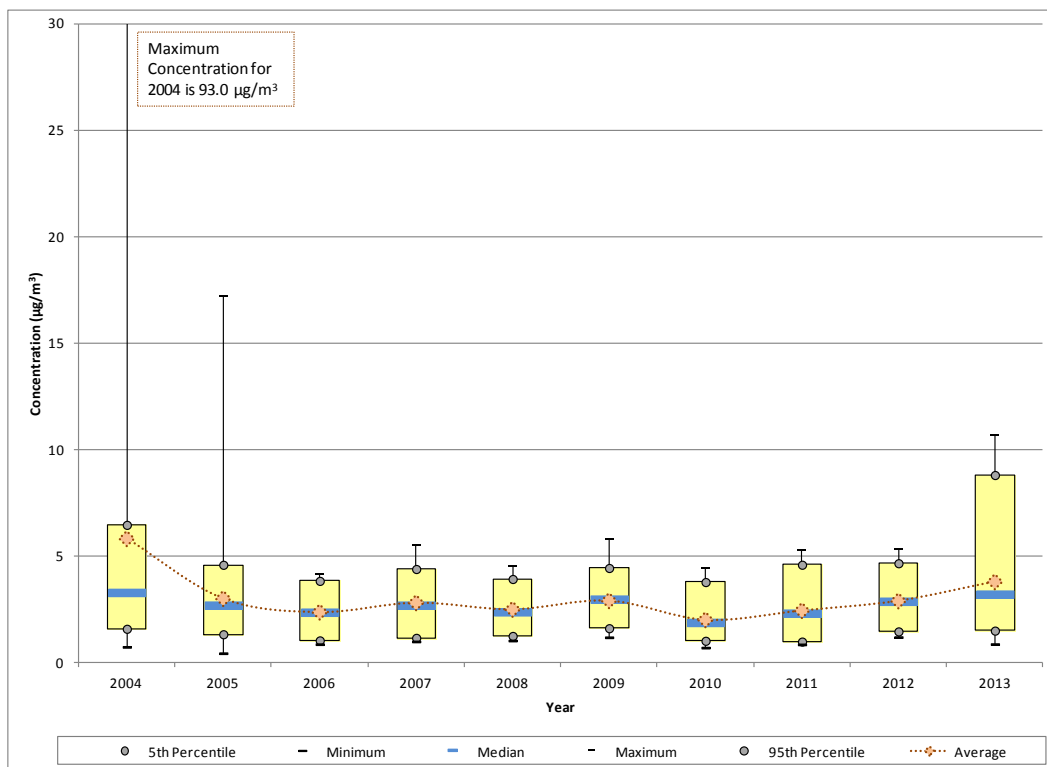


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 8-28 for acenaphthene measurements collected at GPCO include the following:

- Sampling for PAHs at GPCO began in April 2008. Because a full year's worth of data is not available for 2008, a 1-year average is not presented, although the range of measurements is provided.
- Five of the six highest concentrations of acenaphthene were measured at GPCO in the spring of 2012 and ranged from 53.7 ng/m³ to 182 ng/m³. Concentrations measured in 2012 were higher overall compared to other years as nine of the 16 concentrations greater than 30 ng/m³ were measured in 2012 while only one or two were measured in each of the other years of sampling.
- Concentrations of acenaphthene decreased significantly from 2009 to 2010, based on the 1-year averages, after which a steady increasing trend is shown through 2012. Even if the two highest concentrations measured in 2012 were removed from the dataset, the 1-year average concentration for acenaphthene for 2012 would still represent more than a 50 percent increase from 2011. Between 2010 and 2012, the median concentration doubled.
- All of the statistical metrics shown in Figure 8-28 exhibit a decrease for 2013. Both the 1-year average and median concentrations decreased by more than half from 2012 to 2013.

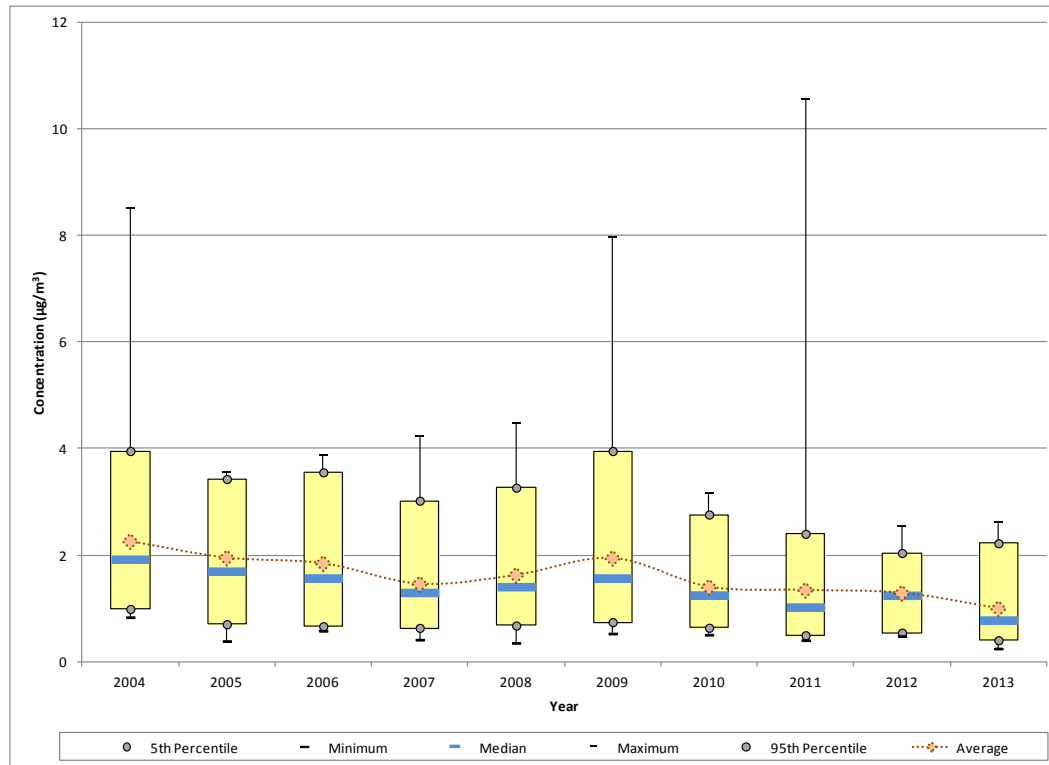
Figure 8-29. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at GPCO



Observations from Figure 8-29 for acetaldehyde measurements collected at GPCO include the following:

- The maximum acetaldehyde concentration was measured at GPCO in 2004. The maximum concentrations measured in subsequent years were significantly lower. The two highest acetaldehyde concentrations ($93.0 \mu\text{g}/\text{m}^3$ and $54.9 \mu\text{g}/\text{m}^3$) were both measured in 2004 and the third highest acetaldehyde concentration ($17.2 \mu\text{g}/\text{m}^3$) was measured in 2005. The remaining six measurements greater than $7 \mu\text{g}/\text{m}^3$ were all measured in 2013 and ranged from 7.00 to $10.7 \mu\text{g}/\text{m}^3$.
- Between 2005 and 2012, the 1-year average concentrations vary by less than $1 \mu\text{g}/\text{m}^3$, ranging from $2.00 \mu\text{g}/\text{m}^3$ (2010) to $3.00 \mu\text{g}/\text{m}^3$ (2005). The 1-year average and median concentrations are both at a minimum for 2010, representing a statistically significant decrease from 2009. The 1-year average concentration increases steadily between 2010 and 2012. The median concentration exhibits a similar pattern.
- An additional increase is also shown for 2013, where all of the statistical metrics except the minimum concentration exhibit an increase. The 1-year average concentration increases by nearly $1 \mu\text{g}/\text{m}^3$ from 2012 to 2013.

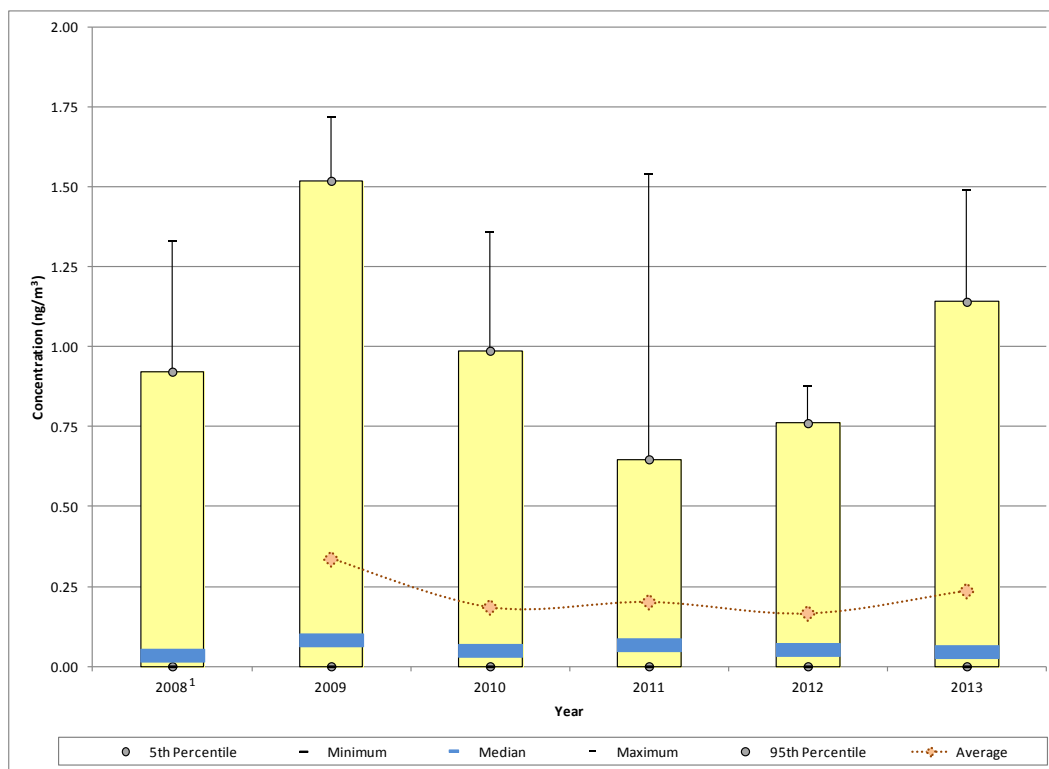
Figure 8-30. Yearly Statistical Metrics for Benzene Concentrations Measured at GPCO



Observations from Figure 8-30 for benzene measurements collected at GPCO include the following:

- The maximum benzene concentration ($10.6 \mu\text{g}/\text{m}^3$) was measured on June 8, 2011. Only three additional concentrations greater than $5 \mu\text{g}/\text{m}^3$ have been measured at GPCO, two in 2004 and one in 2009.
- Concentrations of benzene have a decreasing trend between 2004 and 2007, based on the 1-year average and median concentrations. After a period of increasing for 2008 and 2009, a significant decrease is shown for 2010. This decreasing trend continues through 2013, when most of the statistical metrics are at a minimum. 2013 is the first year that the 1-year average benzene concentration is less than $1 \mu\text{g}/\text{m}^3$. This is also true for the median concentration.
- Even though maximum concentration and 95th percentile increased slightly from 2012 to 2013, the decrease shown for the central tendency statistics is driven by the higher number of concentrations at the lower end of the concentration range for 2013. The number of benzene concentrations less than $1 \mu\text{g}/\text{m}^3$ more than doubled from 2012 (19) to 2013 (43).

Figure 8-31. Yearly Statistical Metrics for Benzo(a)pyrene Concentrations Measured at GPCO

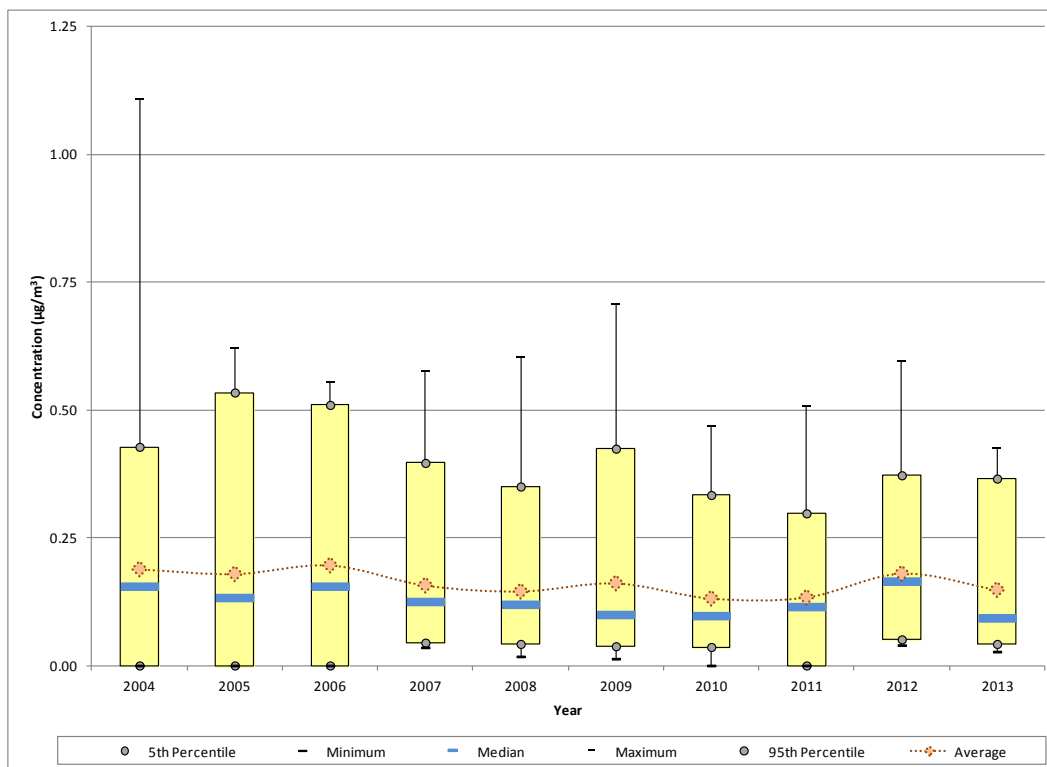


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 8-31 for benzo(a)pyrene measurements collected at GPCO include the following:

- The maximum benzo(a)pyrene concentration (1.72 ng/m³) was measured at GPCO on January 13, 2009. Four of the five highest benzo(a)pyrene concentrations (those greater than 1.50 ng/m³) were measured in 2009, with the fifth measured in 2011.
- For each year where both could be calculated, the median concentration is considerably less than the 1-year average concentration. This is a result of non-detects, for which zeroes are substituted into the calculations. Figure 8-31 shows that the minimum and 5th percentile are zero for all years of sampling, indicating that at least 5 percent of the measurements were non-detects. A review of the data shows that the percentage of non-detects has ranged from 25 percent (2009) to 44 percent (2010). The percentage of non-detects for 2013 is 34 percent.
- The 1-year average concentration decreased by almost half from 2009 to 2010. Between 2010 and 2013, the 1-year average concentration has varied by less than 0.1 ng/m³, ranging from 0.17 ng/m³ (2012) to 0.24 ng/m³ (2013).

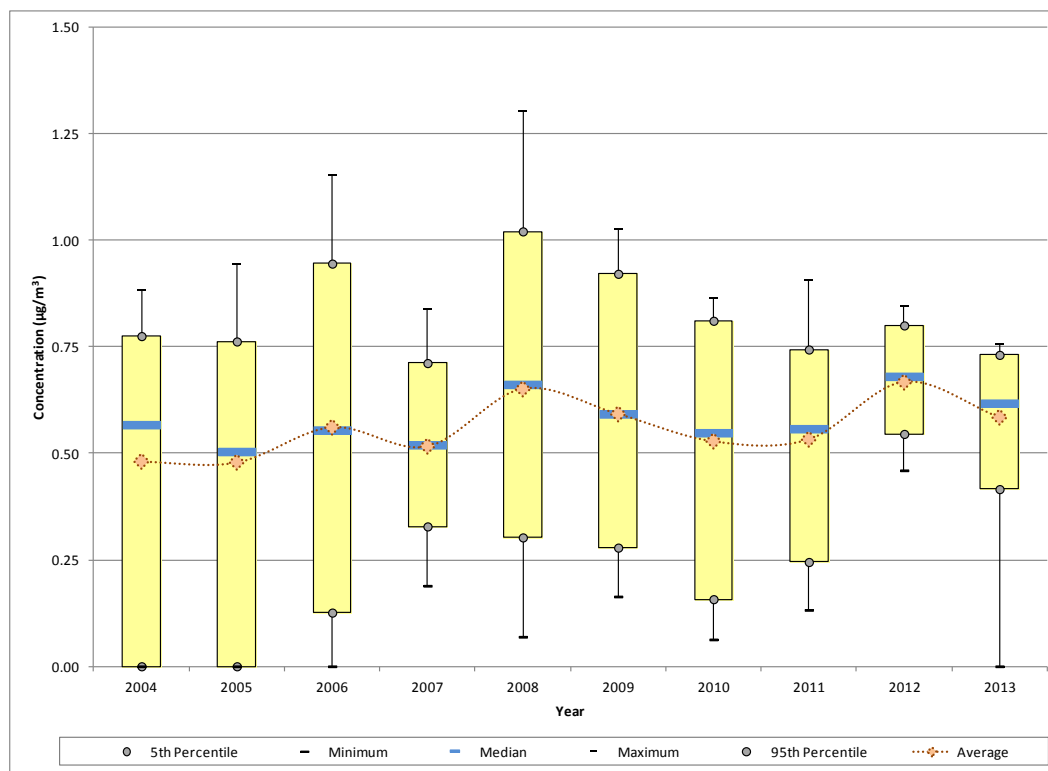
Figure 8-32. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at GPCO



Observations from Figure 8-32 for 1,3-butadiene measurements collected at GPCO include the following:

- The only 1,3-butadiene concentration greater than $1 \mu\text{g}/\text{m}^3$ measured at GPCO was measured on December 11, 2004. The second highest concentration was also measured in 2004 ($0.75 \mu\text{g}/\text{m}^3$), although a similar concentration was measured in 2009 ($0.71 \mu\text{g}/\text{m}^3$).
- The 1-year average concentrations have varied by less than $0.07 \mu\text{g}/\text{m}^3$ over the years of sampling, ranging from $0.132 \mu\text{g}/\text{m}^3$ (2010) to $0.197 \mu\text{g}/\text{m}^3$ (2006).
- The increase in the 1-year average concentration from 2011 to 2012 represents the largest year-to-year change (approximately $0.05 \mu\text{g}/\text{m}^3$). The median also increased by this much from 2011 to 2012. Not only are the measurements at the upper end of the concentration range higher for 2012, as the number of 1,3-butadiene concentrations greater than $0.35 \mu\text{g}/\text{m}^3$ increased from one to six, there were also no non-detects reported for 2012, while there were seven reported for 2011.
- The largest year-to-year change in the median concentration is the decrease shown from 2012 to 2013. Although non-detects were not measured in either year, the number of measurements less than $0.1 \mu\text{g}/\text{m}^3$ nearly doubled from 2012 (17) to 2013 (31), thus representing half of the measurements for 2013.

Figure 8-33. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at GPCO

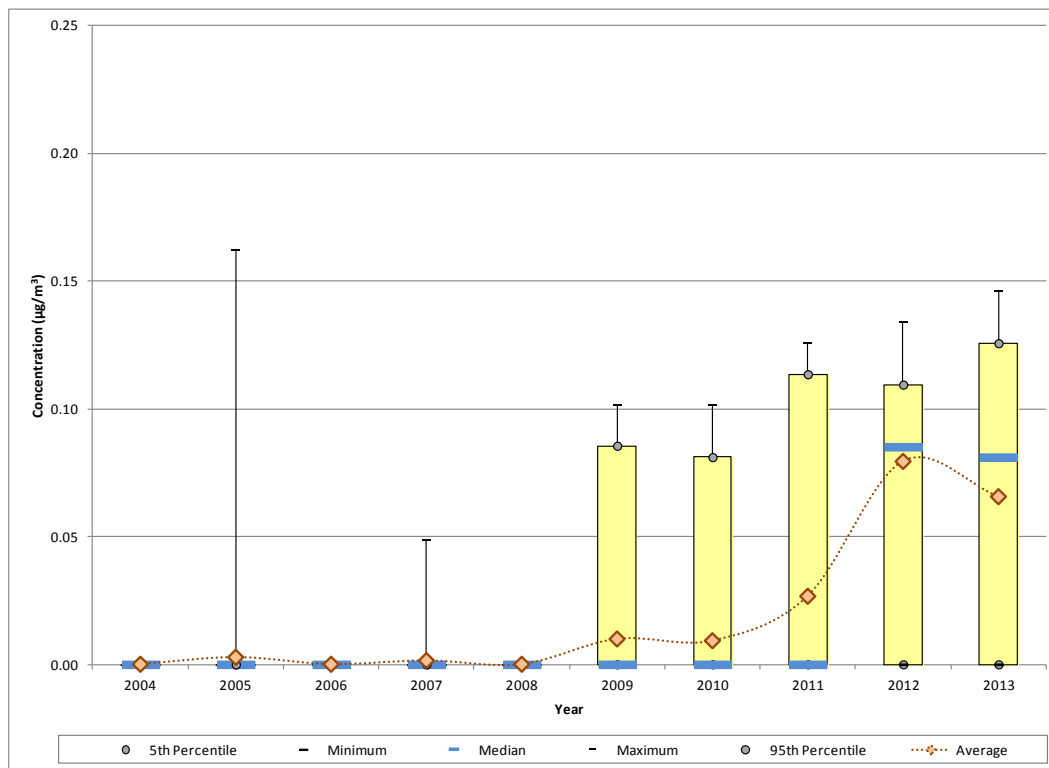


Observations from Figure 8-33 for carbon tetrachloride measurements collected at GPCO include the following:

- Six concentrations of carbon tetrachloride greater than $1 \mu\text{g}/\text{m}^3$ have been measured at GPCO (one in 2006, four in 2008, and one in 2009). Conversely, 16 non-detects have been measured (nine in 2004, five in 2005, and one each in 2006 and 2013).
- The year with the least variability is 2012, with a difference of $0.38 \mu\text{g}/\text{m}^3$ between the minimum and maximum concentrations and a difference of $0.25 \mu\text{g}/\text{m}^3$ between the 5th and 95th percentiles. However, the year with the highest 1-year average and median concentrations ($0.67 \mu\text{g}/\text{m}^3$ and $0.68 \mu\text{g}/\text{m}^3$, respectively) is also 2012. Note the difference between the minimum and 5th percentile for 2012 compared to other years.
- For most of the years of sampling, the median concentration is slightly higher than the 1-year average concentration. This indicates that the concentrations at the lower end of the sampling range are pulling down the 1-year average in the same manner than an outlier can drive an average upward.
- There is a significant increase in the 1-year average concentrations from 2007 to 2008 as the range of concentrations measured doubled from one year to the next. After 2008, a steady decreasing trend is shown through 2010, with little change in the measurements from 2010 to 2011. These statistical parameters increased significantly

from 2011 to 2012, and are at a maximum for the period of sampling. All of the statistical metrics exhibit a decrease from 2012 to 2013, primarily as a result of the higher number of concentrations at the lower end of the concentration range. The number of carbon tetrachloride concentrations less than $0.5 \mu\text{g}/\text{m}^3$ increased from one in 2012 to 11 in 2013.

Figure 8-34. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at GPCO

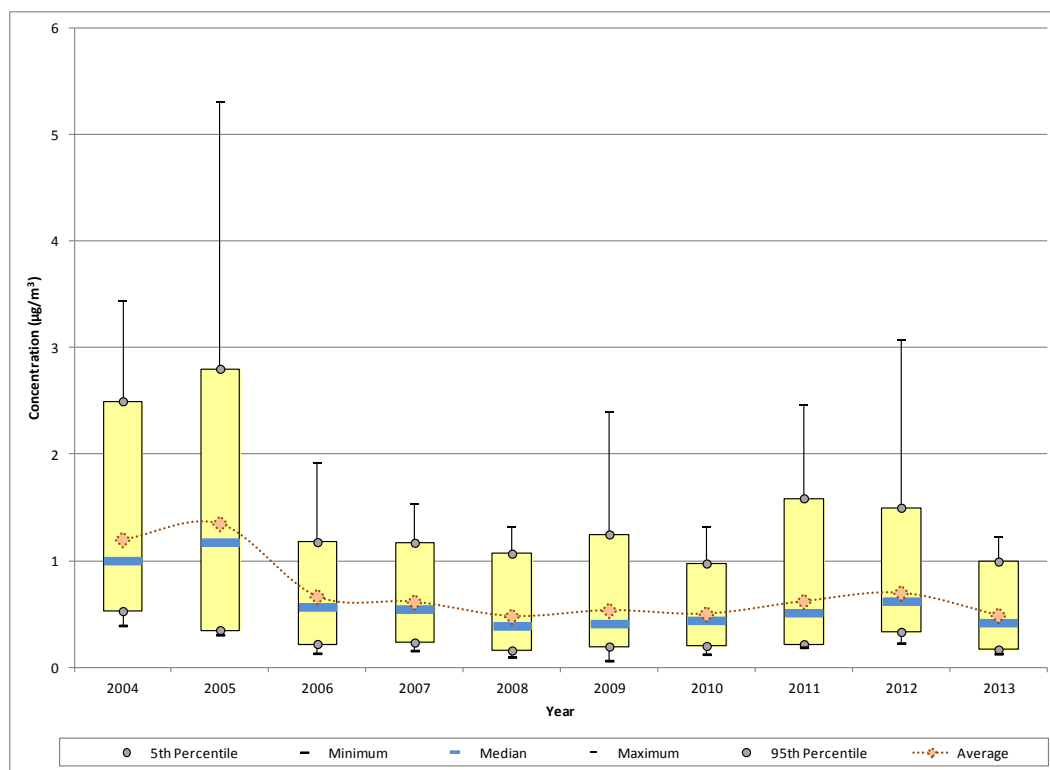


Observations from Figure 8-34 for 1,2-dichloroethane measurements collected at GPCO include the following:

- Between 2004 and 2008 there were only three measured detections of 1,2-dichloroethane measured at GPCO. The median concentration is zero for all years except 2012 and 2013, indicating that at least 50 percent of the measurements were non-detects prior to 2012. The number of measured detections began to increase in 2009, from 12 percent for 2009 and 2010, to 27 percent in 2011, and 90 percent for 2012. The percentage of measured detections decreased slightly for 2013 (74 percent).
- As the number of measured detections increases, so do each of the corresponding statistical metrics shown in Figure 8-34. The number of measured detections increased by 63 percent from 2011 to 2012, thus, the 1-year average and median concentrations exhibit considerable increases.

- The median concentration is greater than the 1-year average concentration for 2012 and 2013. This is because there were still non-detects (or zeros) factoring into the 1-year average concentration for each year, which tend to pull the average down. Excluding non-detects, the minimum concentration for 2012 would be 0.04 $\mu\text{g}/\text{m}^3$, with a difference between the minimum and maximum concentrations measured for 2012 of less than 0.1 $\mu\text{g}/\text{m}^3$. This is also true for 2013.
- Even though the maximum and 95th percentile increased from 2012 to 2013, the 1-year average and median concentrations decreased. This results from a greater number of non-detects for 2013 (nearly three times as many).

Figure 8-35. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at GPCO



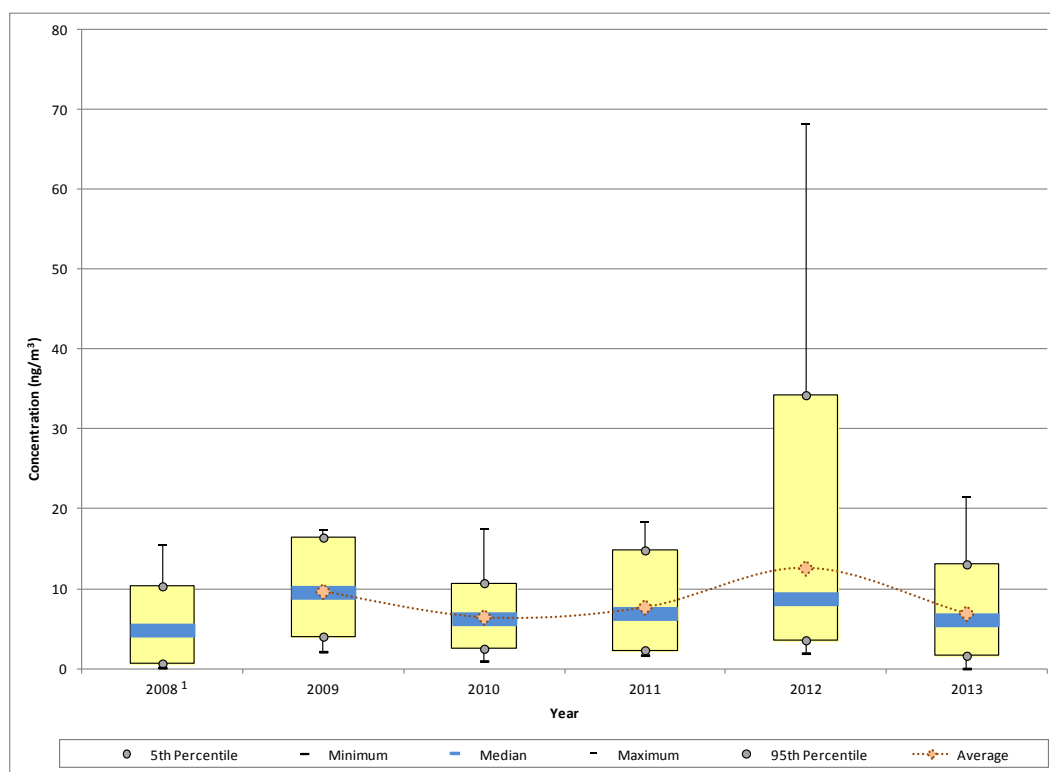
Observations from Figure 8-35 for ethylbenzene measurements collected at GPCO include the following:

- The maximum ethylbenzene concentration was measured at GPCO in 2005 (5.31 $\mu\text{g}/\text{m}^3$), as was the second highest concentration (3.96 $\mu\text{g}/\text{m}^3$). Three additional concentrations greater than 3 $\mu\text{g}/\text{m}^3$ have been measured at GPCO, two in 2004 and one in 2012. All but three of the 15 measurements greater than 2 $\mu\text{g}/\text{m}^3$ (but less than 3 $\mu\text{g}/\text{m}^3$) were also measured during these two years.
- The 1-year average concentration increased slightly from 2004 to 2005, although there is a relatively high level of variability in the measurements. A significant

decrease in all of the statistical parameters is shown from 2005 to 2006, and the slight decreasing trend continues through 2008.

- Although the maximum concentration measured increased from 2008 to 2009, only a slight change in the 1-year and median concentrations is exhibited for 2009. The range of concentrations measured in 2010 is similar to the range of concentrations measured in 2008. An increasing trend in the 1-year average concentration is shown from 2010 through 2012. The median concentration exhibits a slight increasing trend beginning with 2009 and continuing through 2012.
- All of the statistical parameters exhibit a decrease from 2012 to 2013. The maximum ethylbenzene concentration measured in 2013 is the lowest maximum concentration for any given year of sampling shown in Figure 8-35.

Figure 8-36. Yearly Statistical Metrics for Fluorene Concentrations Measured at GPCO



¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

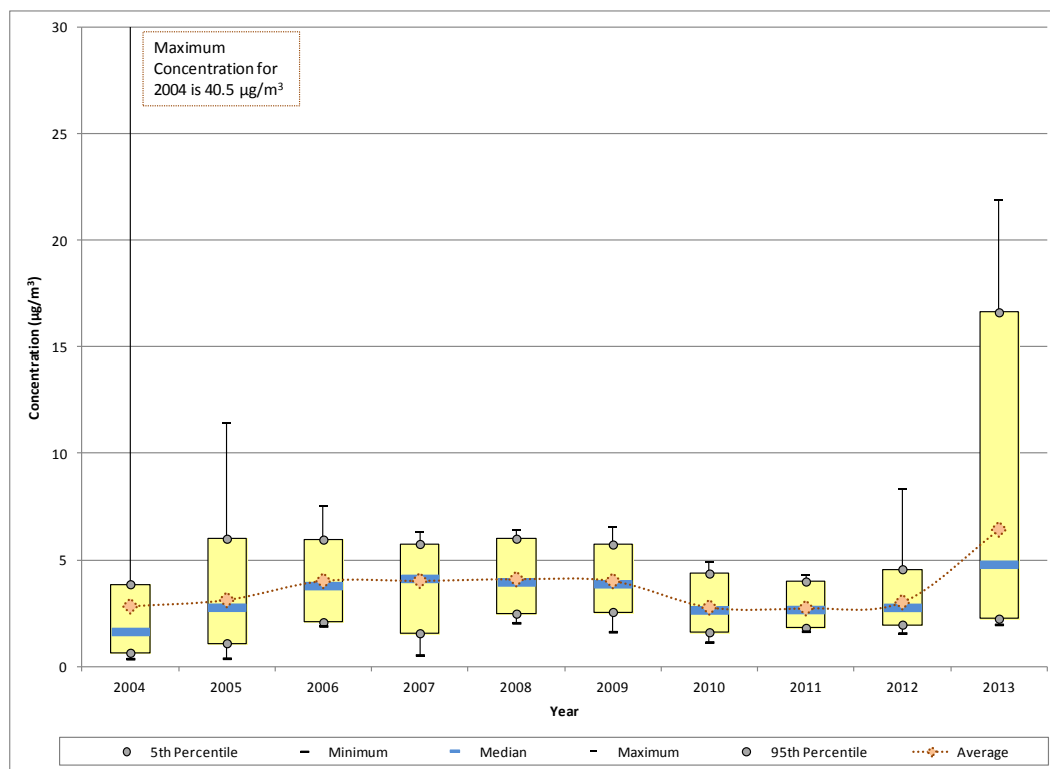
Observations from Figure 8-36 for fluorene measurements collected at GPCO include the following:

- The trends graph for fluorene resembles the trends graph for acenaphthene shown in Figure 8-28.
- The range of measurements collected at GPCO spans between 15 ng/m³ and 17 ng/m³ for each year of sampling until 2012. For 2012, the range of measurements is

significantly higher, with a maximum concentration nearly four times higher than those measured in previous years. Eight of the nine highest acenaphthene concentrations (those greater than 20 ng/m³) were measured at GPCO in 2012, with the one additional concentration measured in 2013.

- The 1-year average concentration decreased significantly from 2009 to 2010. The slight increase from 2010 to 2011 is followed by a more significant increase for 2012. The 1-year average concentration then decreased by half from 2012 to 2013. The median concentration has a similar pattern. The number of concentrations at the upper end of the concentration range decreased considerably for 2013; the number of measurements greater than 10 ng/m³ decreased from 29 in 2012 to nine in 2013. In addition, the only two non-detects of acenaphthene measured at GPCO over the period of sampling were measured in 2013.

Figure 8-37. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at GPCO



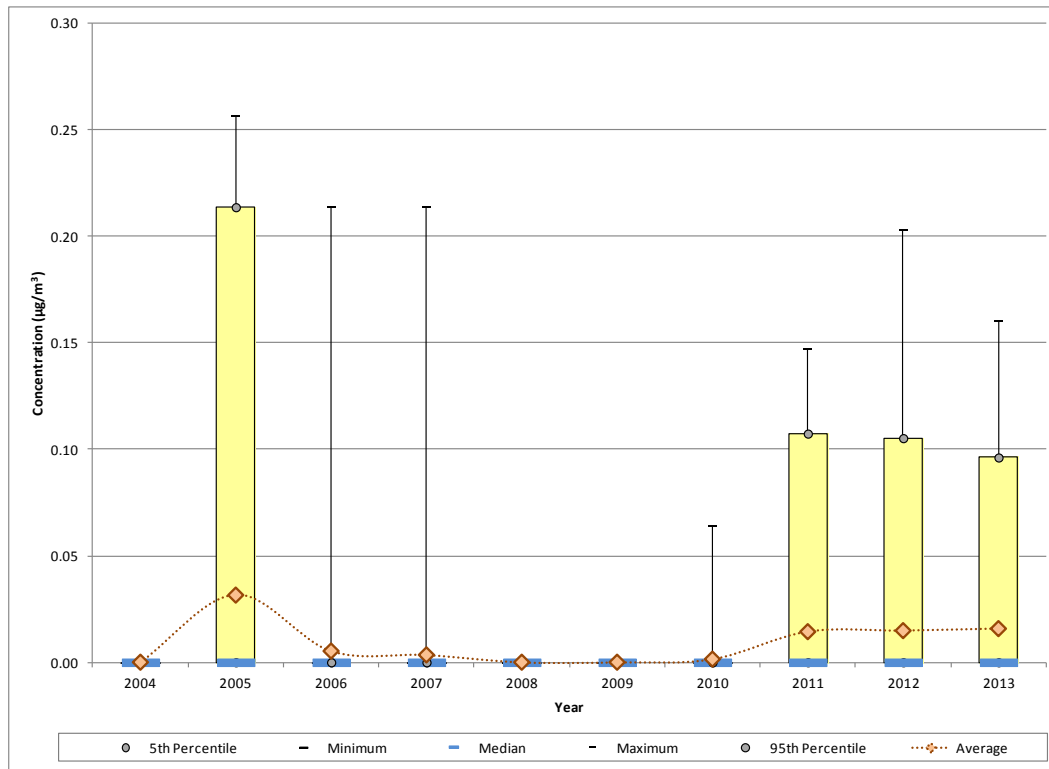
Observations from Figure 8-37 for formaldehyde measurements collected at GPCO include the following:

- The trends graph for formaldehyde resembles the trends graph for acetaldehyde in that the maximum formaldehyde concentration (40.5 µg/m³) was measured in 2004 and is significantly higher than the maximum concentrations measured in subsequent years. The second highest concentration was also measured in 2004 (23.5 µg/m³); these two concentrations of formaldehyde were measured on the same days in 2004

as the two highest acetaldehyde concentrations. The next eight highest formaldehyde concentrations were measured in 2013 and ranged from 13.9 $\mu\text{g}/\text{m}^3$ to 21.9 $\mu\text{g}/\text{m}^3$.

- Even with decreasing maximum concentrations, the 1-year average concentrations have an increasing trend through 2006. The 1-year average concentration is approximately 4 $\mu\text{g}/\text{m}^3$ for each year between 2006 and 2009. A significant decrease in all of the statistical metrics is shown for 2010. Although an even smaller range of concentrations was measured in 2011, there is little change in the 1-year average concentration. With a few higher concentrations measured in 2012, the 1-year average calculated for 2012 is slightly higher than the 1-year average concentrations for the previous two years, although the increase is not statistically significant.
- All of the statistical parameters exhibit increases for 2013, particularly those representing concentrations at the upper end of the concentration range. The 1-year average concentration for 2013 is greater than the maximum concentrations measured in several of the previous years and is greater than the 95th percentile for each of the previous years.

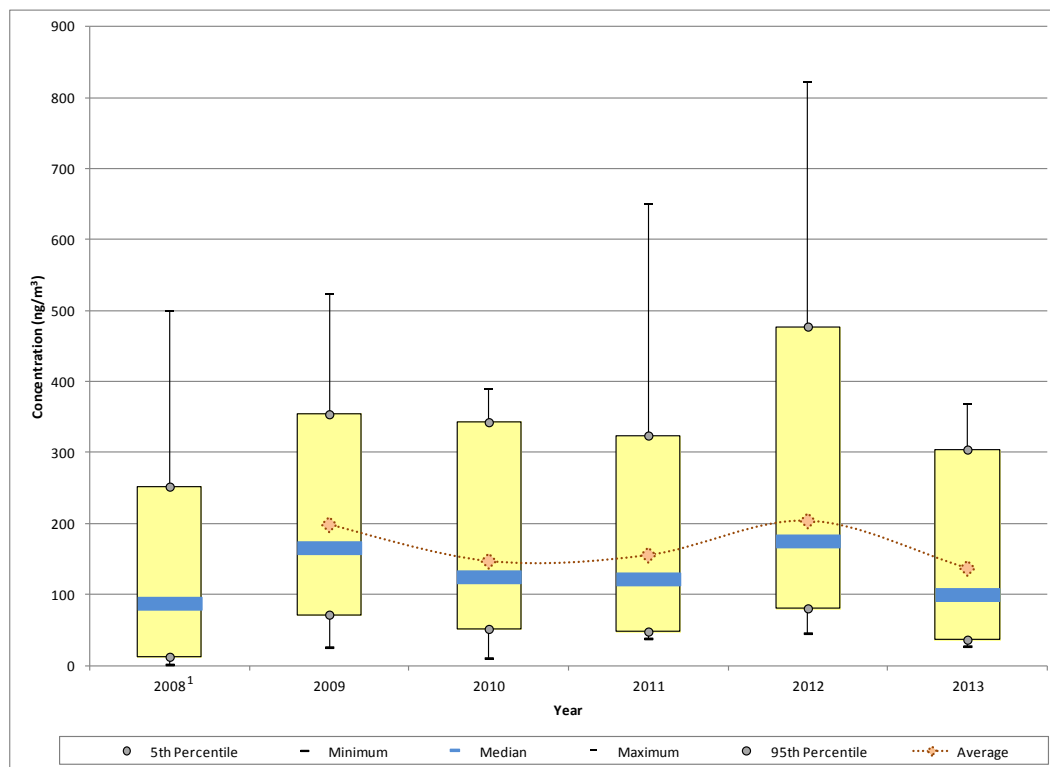
Figure 8-38. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at GPCO



Observations from Figure 8-38 for hexachloro-1,3-butadiene measurements collected at GPCO include the following:

- The number of measured detections for each year is very low, from zero measured detections in 2004, 2008, and 2009 to 11 (or 18 percent) for 2013. This explains why the minimum, 5th percentile, and median concentrations (and in some cases, the 1-year averages) are all zero for each year of sampling. The detection rate has increased slightly over the last few years. Additional years of sampling are needed to determine if this trend continues.
- The maximum hexachloro-1,3-butadiene concentration was measured during 2005 ($0.26 \mu\text{g}/\text{m}^3$). Although nine additional measurements greater than $0.20 \mu\text{g}/\text{m}^3$ have been measured at GPCO, all but one of these were measured between 2005 and 2007.
- The large number of non-detects, and thus zeroes substituted into the calculations, combined with few measured detections results in relatively low 1-year average concentrations with very large confidence intervals.

Figure 8-39. Yearly Statistical Metrics for Naphthalene Concentrations Measured at GPCO

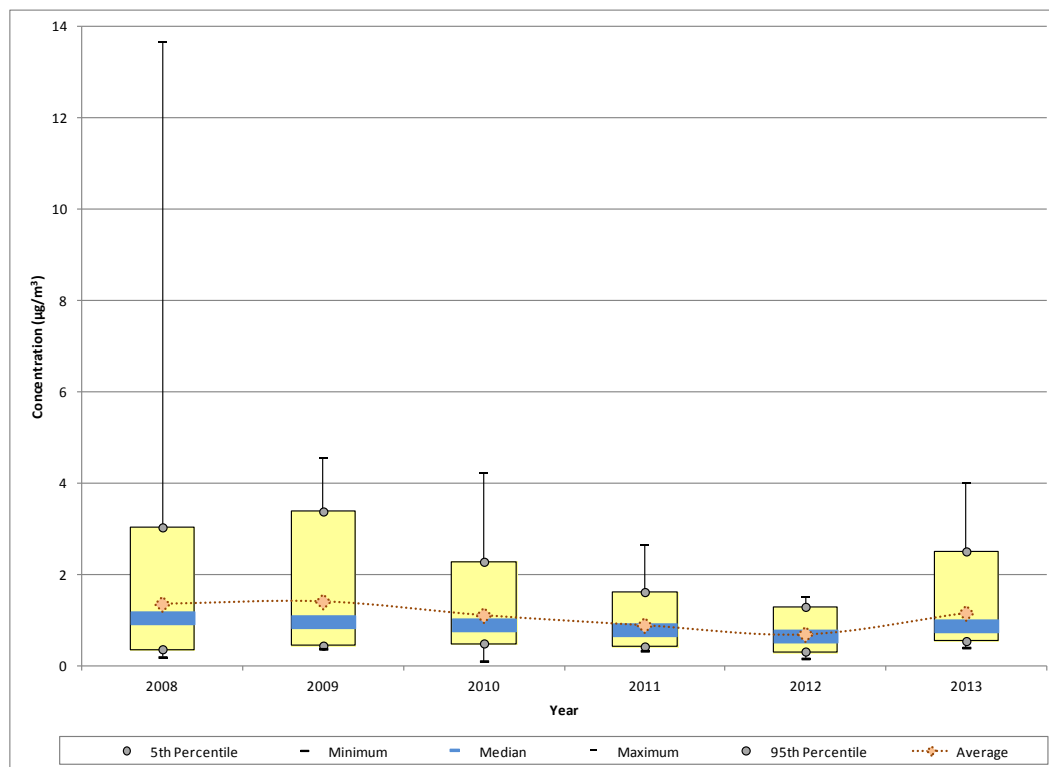


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 8-39 for naphthalene measurements collected at GPCO include the following:

- The maximum naphthalene concentration measured at GPCO was measured in 2012 (822 ng/m³). Concentrations of 400 ng/m³ or higher have been measured in all years of sampling except 2010 and 2013.
- The trends graph for naphthalene resembles the trends graphs for acenaphthene and fluorene shown in Figures 8-28 and 8-36. The 1-year average concentration for naphthalene decreased significantly from 2009 to 2010. A slight increase from 2010 to 2011 is followed by an additional increase for 2012. All of the statistical parameters increased from 2011 to 2012. The smallest range of naphthalene concentrations was measured in 2013 and all of the statistical parameters decreased from 2012 to 2013.
- The median concentrations shown in Figure 8-39 follow a similar pattern as the 1-year average concentrations.

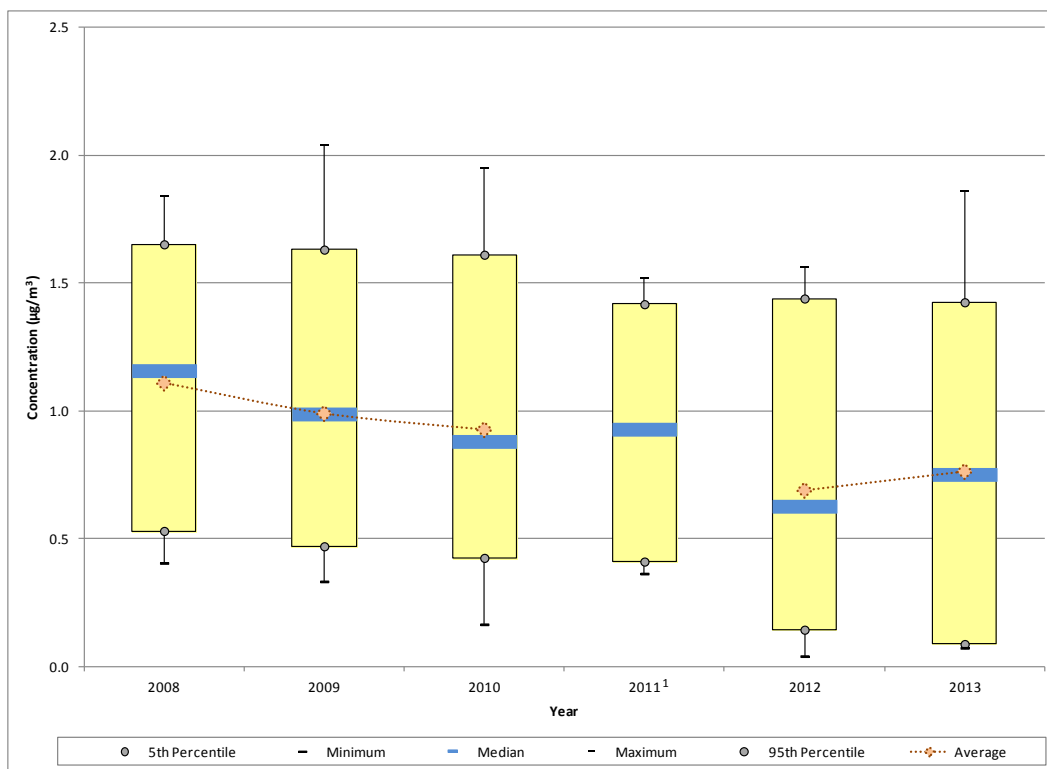
Figure 8-40. Yearly Statistical Metrics for Benzene Concentrations Measured at BRCO



Observations from Figure 8-40 for benzene measurements collected at BRCO include the following:

- BRCO began sampling benzene under the NMP in January 2008. The maximum benzene concentration ($13.66 \mu\text{g}/\text{m}^3$) was measured on July 29, 2008 and is three times higher than the next highest concentration ($4.55 \mu\text{g}/\text{m}^3$, measured on January 7, 2009), although a similar concentration was also measured on December 21, 2009 ($4.49 \mu\text{g}/\text{m}^3$). The only other benzene concentration greater than $4 \mu\text{g}/\text{m}^3$ was measured at BRCO in 2010.
- The statistical parameters for benzene exhibit a steady decreasing trend over the years of sampling at BRCO through 2012. Prior to 2013, the 1-year average concentration decreased by roughly half, from a maximum of $1.39 \mu\text{g}/\text{m}^3$ in 2009 to a minimum of $0.68 \mu\text{g}/\text{m}^3$ in 2012. The median concentration has also decreased, from $1.05 \mu\text{g}/\text{m}^3$ in 2008 to $0.65 \mu\text{g}/\text{m}^3$ in 2012.
- The difference between the 1-year average and the median concentration has decreased as well for each year, from a difference between the two of $0.43 \mu\text{g}/\text{m}^3$ for 2009 to $0.03 \mu\text{g}/\text{m}^3$ for 2012. This indicates a decreasing variability in the measurements.
- All of the statistical metrics exhibit an increase from 2012 to 2013, returning to concentration levels similar to 2010.

Figure 8-41. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at PACO



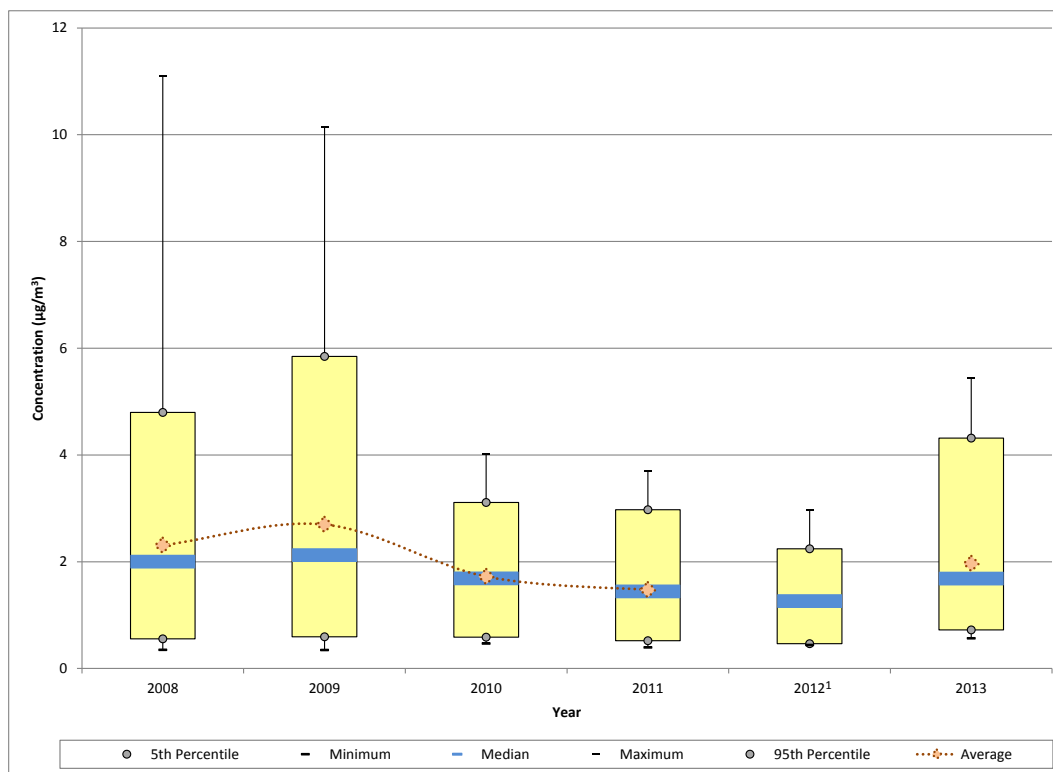
¹ A 1-year average is not presented due to low method completeness in 2011.

Observations from Figure 8-41 for acetaldehyde measurements collected at PACO include the following:

- PACO began sampling acetaldehyde under the NMP in February 2008. A 1-year average concentration is not presented for 2011 due to low method completeness. Note that carbonyl compounds are sampled on a 1-in-12 sampling schedule at PACO.
- The maximum acetaldehyde concentration ($2.04 \mu\text{g}/\text{m}^3$) was measured at PACO on January 13, 2009 and is the only acetaldehyde concentration greater than $2 \mu\text{g}/\text{m}^3$ measured at this site.
- The 1-year average concentrations have a decreasing trend through 2012, with the exception of 2011, the only year for which a 1-year average is not presented. Nearly all of the statistical parameters shown also have a decreasing trend. For 2011, the maximum, 95th percentile, and 5th percentile all exhibit decreases (albeit slight), while the median and minimum concentrations increased. Even though the range of measurements is at a minimum for 2011, the concentrations greater than $1 \mu\text{g}/\text{m}^3$ represent a higher percentage of measurements for 2011 compared to the previous year.
- For 2013, both the 1-year average and median concentrations exhibit an increase. The range within which the majority of the measurements fall, indicated by the 5th and

95th percentiles, is at a maximum for 2013 over the years of sampling, indicating an increase in the variability of the measurements.

Figure 8-42. Yearly Statistical Metrics for Benzene Concentrations Measured at PACO



¹ A 1-year average is not presented due to low method completeness in 2012.

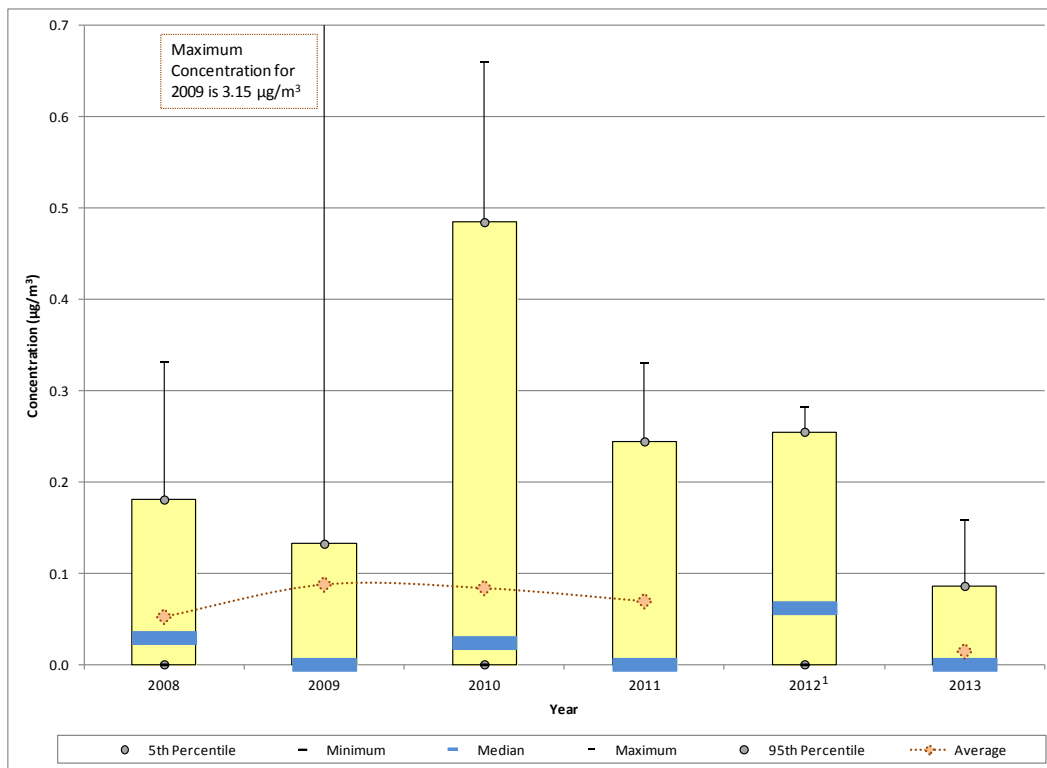
Observations from Figure 8-42 for benzene measurements collected at PACO include the following:

- PACO began sampling SNMOCs under the NMP in January 2008. A 1-year average concentration is not presented for 2012 due to low method completeness resulting sampler issues.
- The maximum benzene concentration ($11.1 \mu\text{g}/\text{m}^3$) was measured on October 15, 2008. The next highest measurement ($10.1 \mu\text{g}/\text{m}^3$) was measured three months later on January 7, 2009. The third highest concentration was measured on the next sample day in 2009 but was considerably less ($7.52 \mu\text{g}/\text{m}^3$). The eight highest benzene concentrations (those greater than $5.50 \mu\text{g}/\text{m}^3$) were all measured in either 2008 or 2009.
- Even though the maximum concentration decreased from 2008 to 2009, benzene concentrations increased overall from 2008 to 2009, as indicated by the increases in the 1-year average, median, and 95th percentile. Concentrations of benzene exhibit a significant decreasing trend between 2009 and 2010, when the maximum and 95th percentile decreased by nearly half. This decreasing trend continued into 2011 and

2012. Although a 1-year average concentration could not be calculated for 2012, the maximum, 95th percentile, and median concentrations are at a minimum for 2012. No benzene concentrations greater than $3 \mu\text{g}/\text{m}^3$ were measured in 2012.

- The range of benzene concentrations increased considerably from 2012 to 2013. The range within which the majority of the measurements fall, indicated by the 5th and 95th percentiles, is at its largest since 2009. Nine benzene concentrations greater than the maximum concentration for 2012 ($2.97 \mu\text{g}/\text{m}^3$) were measured in 2013.

Figure 8-43. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at PACO



¹ A 1-year average is not presented due to low method completeness in 2012.

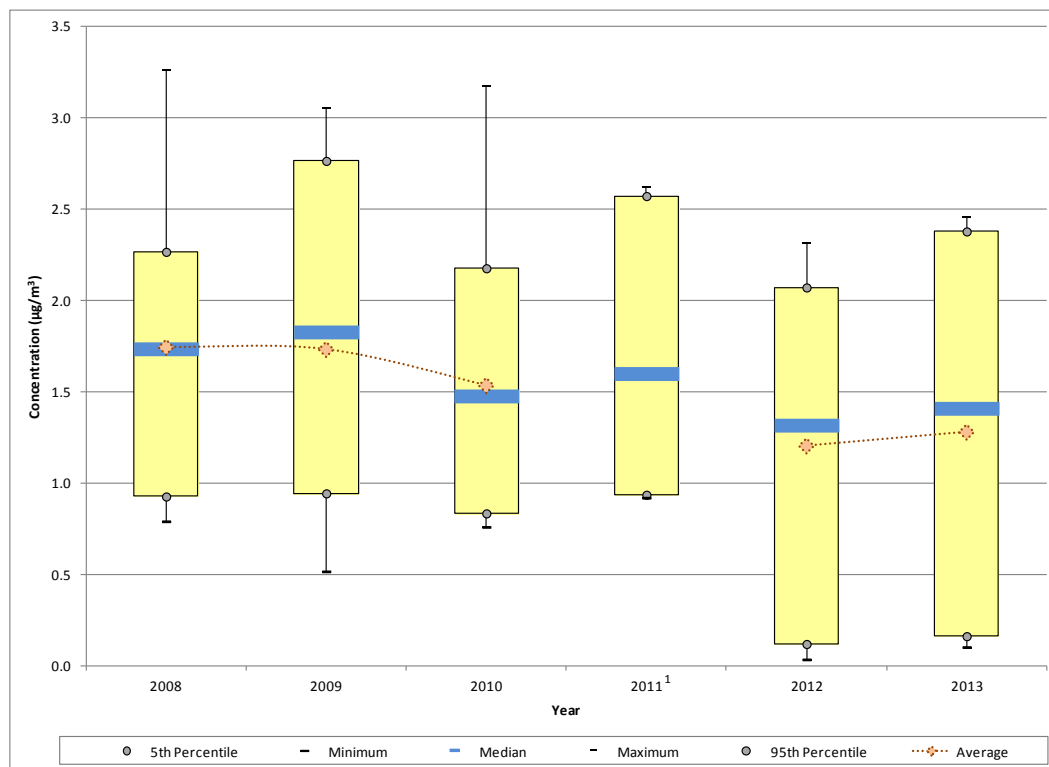
Observations from Figure 8-43 for 1,3-butadiene measurements collected at PACO include the following:

- The maximum 1,3-butadiene concentration ($3.15 \mu\text{g}/\text{m}^3$) was measured on December 27, 2009 and is the only 1,3-butadiene measurement greater than $1 \mu\text{g}/\text{m}^3$ measured at this site.
- The increase in the 1-year average concentration from 2008 to 2009 is a result of this outlier concentration measured in 2009. The second highest concentration measured in 2009 is substantially less ($0.19 \mu\text{g}/\text{m}^3$). Excluding the maximum concentration for 2009 would result in a 1-year average concentration of only $0.028 \mu\text{g}/\text{m}^3$ (rather than $0.88 \mu\text{g}/\text{m}^3$), and thus a decrease in the 1-year average concentration by almost half.

from 2008 to 2009. Note that the median 1,3-butadiene concentration for 2009 is zero, indicating that at least half of the measurements for 2009 are non-detects.

- The second, third, fourth, and fifth highest 1,3-butadiene concentrations measured at PACO were all measured in December 2010 and ranged from 0.39 $\mu\text{g}/\text{m}^3$ to 0.66 $\mu\text{g}/\text{m}^3$. The next highest concentration for this year was also measured in December but was considerably less (0.16 $\mu\text{g}/\text{m}^3$). The 95th percentile for 2010 is greater than the maximum concentration measured for all other years except 2009 and more than tripled from 2009 to 2010. Even though half of the measurements in 2010 were non-detects, the December measurements for 2010 are driving the top-end statistical parameters upward.
- Nearly all of the statistical parameters decreased from 2010 to 2011 except the minimum and 5th percentile, which are zero for both of these years.
- Prior to 2012, the number of non-detects measured at PACO has ranged from 47 percent (2008) to 58 percent (2009 and 2011). This explains why the median concentration is at or near zero for these years. For 2012, the number of non-detects is at a minimum (29 percent) and explains why the median increased considerably although the range of measurements did not change much from 2011 and 2012.
- For 2013, the median concentration returned to zero as the number of non-detects increased from 29 percent in 2012 to 83 percent for 2013. The maximum and 95th percentile decreased considerably for 2013 and are at a minimum for the period of sampling, as is the 1-year average concentration.

Figure 8-44. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at PACO



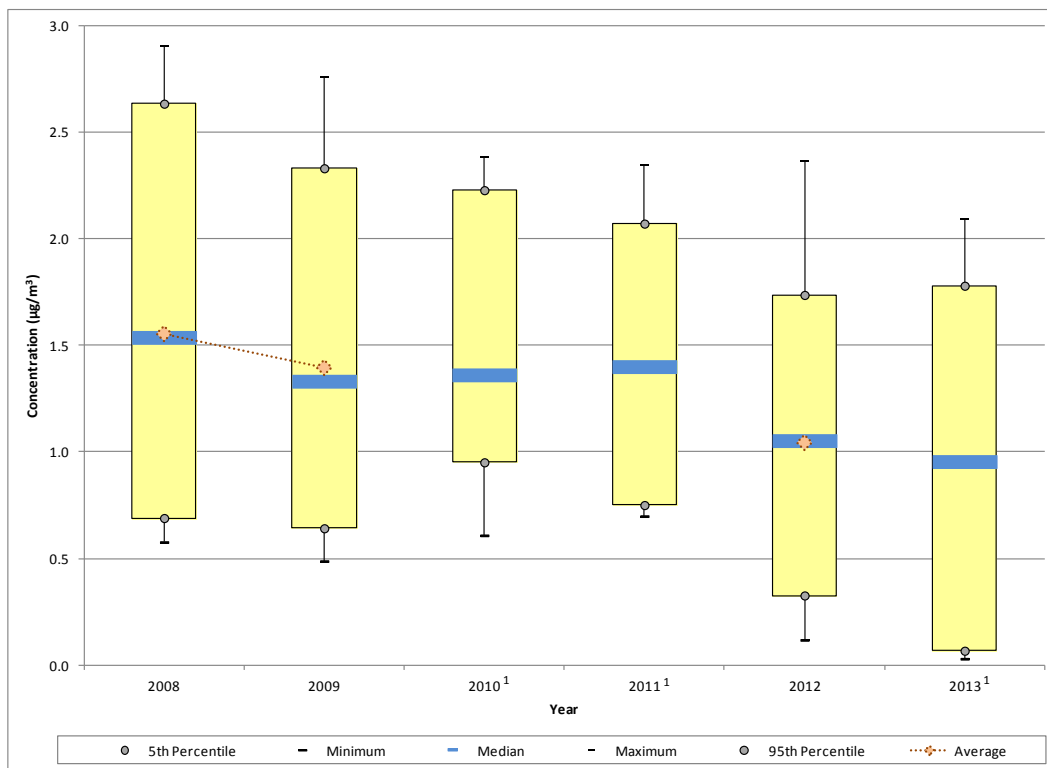
¹ A 1-year average is not presented due to low method completeness in 2011.

Observations from Figure 8-44 for formaldehyde measurements collected at PACO include the following:

- Only four formaldehyde concentrations greater than $3 \mu\text{g}/\text{m}^3$ have been measured at PACO (one in 2008, two in 2009, and one in 2010).
- The 1-year average concentration did not change between 2008 and 2009. The decreases in the minimum and maximum concentrations for 2009 are countered by the increase in the measurements at the higher end of the concentration range, as indicated by the increases in the median and 95th percentile.
- The data distribution statistics for 2010 resemble those for 2008, although the 1-year average and median concentrations both exhibit decreases.
- Although the maximum concentration decreased for 2011, all of the other statistical parameters that could be calculated exhibit increases from 2010 to 2011.
- All of the statistical parameters exhibit decreases from 2011 to 2012, particularly at the lower end of the concentration range. This year has the greatest number of measurements less than $1 \mu\text{g}/\text{m}^3$ (nine). Note that the median concentration is greater than the 1-year average for 2012. This indicates that the measurements at the lower end of the concentration range are pulling down the 1-year average concentration. A

similar observation can be made for 2013. 2012 and 2013 account for all nine of the formaldehyde concentrations less than $0.5 \mu\text{g}/\text{m}^3$ measured at PACO.

Figure 8-45. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at RICO

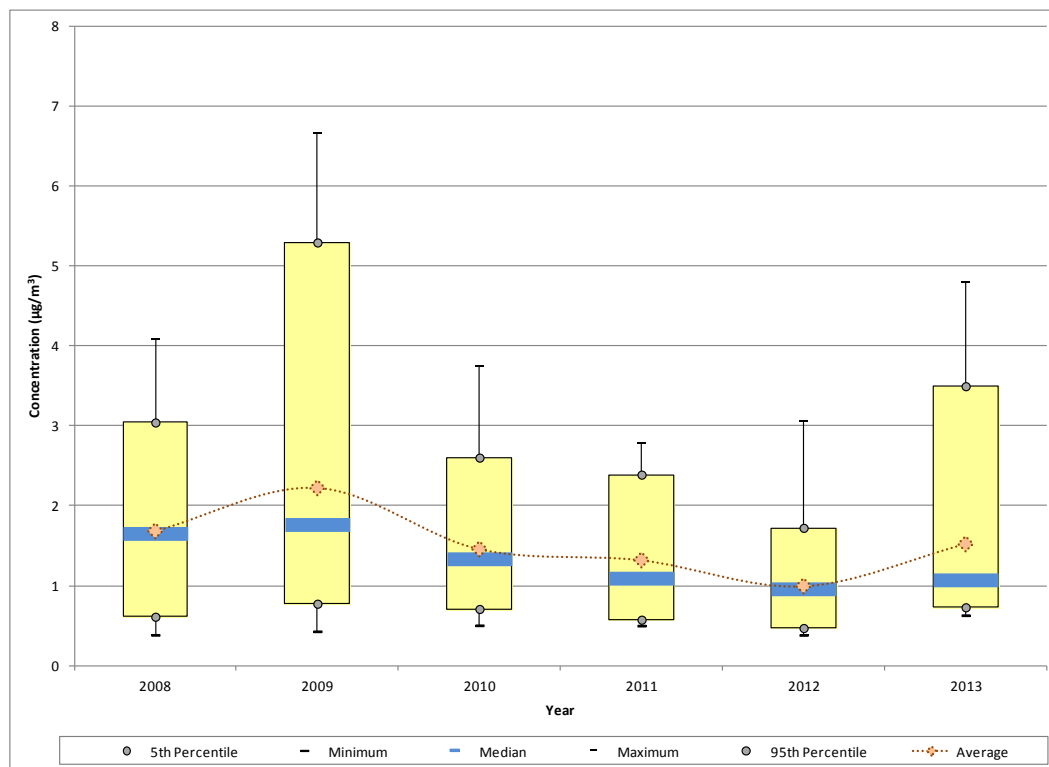


¹ A 1-year average is not presented due to low method completeness in 2010, 2011, and 2013.

Observations from Figure 8-45 for acetaldehyde measurements collected at RICO include the following:

- RICO began sampling carbonyl compounds under the NMP in February 2008. A 1-year average concentration is not presented for 2010, 2011, or 2013 due to low method completeness. However, the range of measurements is provided for each of these years.
- The maximum acetaldehyde concentration ($2.91 \mu\text{g}/\text{m}^3$) was measured at RICO in July 2008, although a similar concentration was also measured two sample days prior.
- Because few 1-year average concentrations are shown, a distinct trend is hard to identify. However, the measurements appear to have an overall decreasing trend, based on the decreases shown for nearly all of the other statistical parameters.
- The minimum and 5th percentiles decreased considerably from 2011 to 2012 and into 2013. 2012 and 2013 account for the 10 lowest concentrations (those less than $0.45 \mu\text{g}/\text{m}^3$) of acetaldehyde measured at RICO.

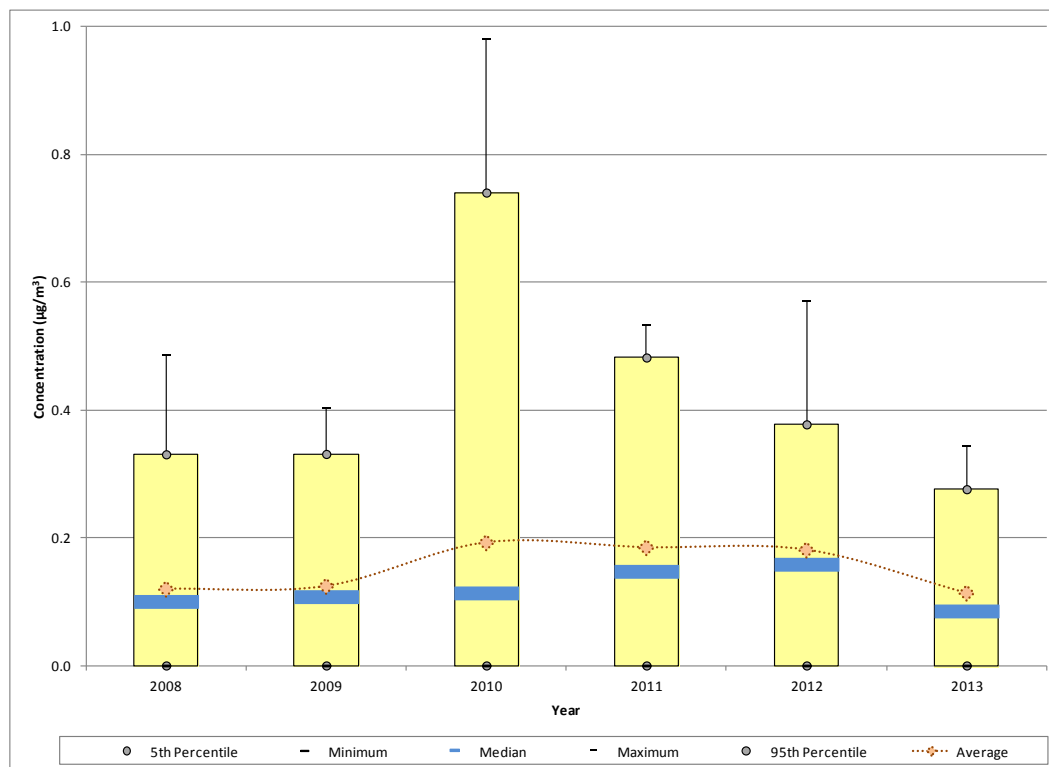
Figure 8-46. Yearly Statistical Metrics for Benzene Concentrations Measured at RICO



Observations from Figure 8-46 for benzene measurements collected at RICO include the following:

- RICO began sampling SNMOCs under the NMP in January 2008.
- The maximum benzene concentration ($6.67 \mu\text{g}/\text{m}^3$) was measured in January 2009. The six highest benzene concentrations measured at RICO were all measured in 2009.
- The number of measurements greater than $2 \mu\text{g}/\text{m}^3$ increased from 18 to 24 from 2008 to 2009, then decreased by half for 2010 and continued to decrease, reaching a minimum of two for 2012. This explains the increase in the statistical parameters shown from 2008 to 2009 as well as the subsequent decreases in the years that follow. The median concentration is $0.96 \mu\text{g}/\text{m}^3$ for 2012, indicating that nearly half of the measurements are less than $1 \mu\text{g}/\text{m}^3$. The 1-year average concentration is also less than $1 \mu\text{g}/\text{m}^3$ for 2012.
- All of the statistical parameters exhibit increases for 2013. The number of concentrations greater than $2 \mu\text{g}/\text{m}^3$ increased six-fold from 2012 to 2013.
- The statistical metrics shown for RICO's benzene concentrations resemble the ones shown for benzene concentrations measured at PACO (and to a lesser extent BRGO), as all three sites exhibit a decreasing trend through 2012 followed by a considerable increase for 2013.

Figure 8-47. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at RICO

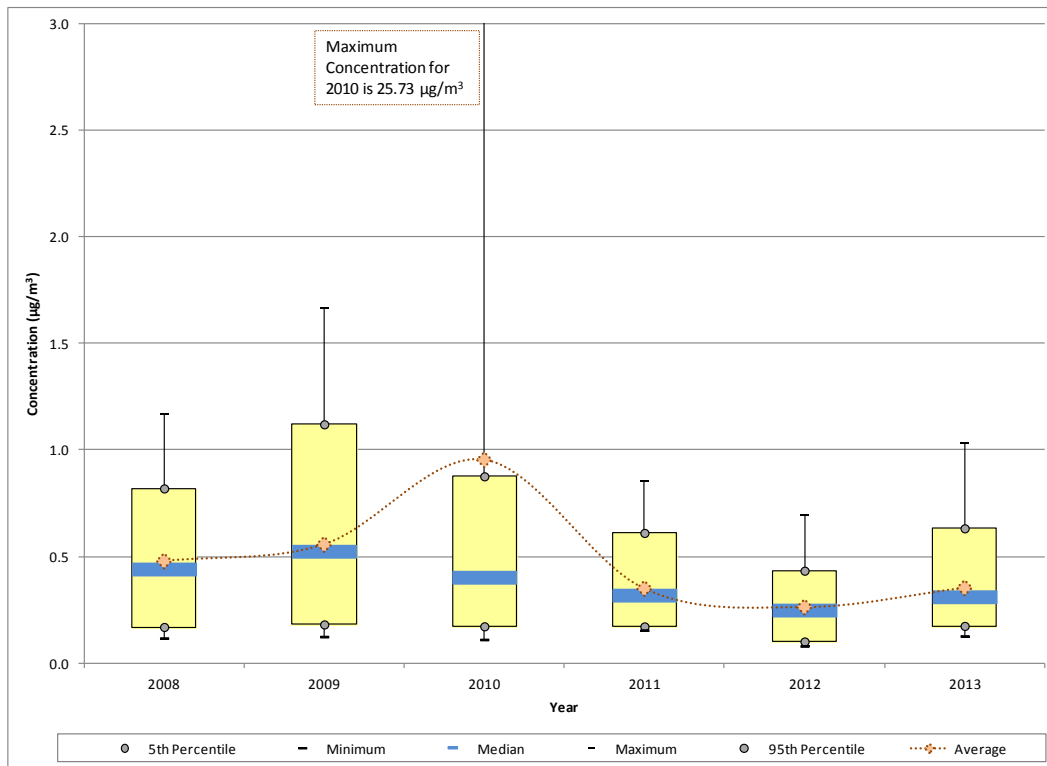


Observations from Figure 8-47 for 1,3-butadiene measurements collected at RICO include the following:

- The five highest 1,3-butadiene concentrations were all measured at RICO in December 2010 and ranged from 0.57 $\mu\text{g}/\text{m}^3$ to 0.98 $\mu\text{g}/\text{m}^3$. Higher 1,3-butadiene concentrations were also measured at PACO during December 2010.
- With the exception of the maximum concentration, the range of concentrations measured in 2008 and 2009 were similar to each other, as indicated by most of the statistical parameters shown. This was followed by an increase in the magnitude of the measurements in 2010. Even though the 95th percentile more than doubled and the 1-year average increased by more than 50 percent, the median concentration changed very little for 2010. This indicates that there are roughly the same number of measurements at the lower end of the concentration range while the measurements at the higher end of the concentration range are driving the 1-year average concentration upward.
- Although the range of concentrations measured decreased from 2010 to 2011, the 1-year average concentration decreases only slightly while the median concentration increases. The 1-year average also decreases slightly for 2012 while the median continues its subtle increase.
- Most of the statistical parameters exhibit decreases from 2012 to 2013 (the minimum and 5th percentile both stay the same), with the median concentration decreasing by

half. Overall, the concentrations measured were lower in 2013. The number of concentrations greater than $0.25 \mu\text{g}/\text{m}^3$ decreased from 17 in 2012 to five in 2013; further, the number of concentrations less than $0.1 \mu\text{g}/\text{m}^3$ increased from 15 in 2012 to 31 in 2013, accounting for more than half of the concentrations measured in 2013.

Figure 8-48. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at RICO

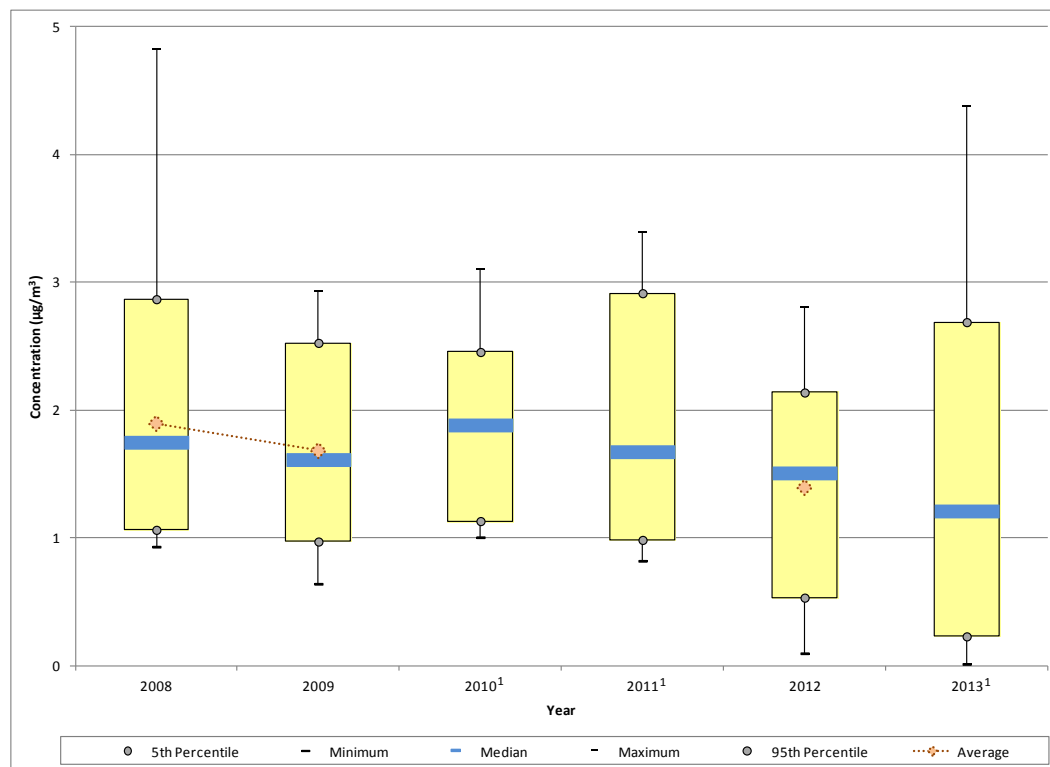


Observations from Figure 8-48 for ethylbenzene measurements collected at RICO include the following:

- The maximum ethylbenzene concentration measured at RICO was measured on August 18, 2010 ($25.7 \mu\text{g}/\text{m}^3$). The next highest concentration was also measured in 2010 but was considerably less ($6.72 \mu\text{g}/\text{m}^3$). No other ethylbenzene concentrations greater than $2 \mu\text{g}/\text{m}^3$ have been measured at RICO and few greater than $1 \mu\text{g}/\text{m}^3$ have been measured at this site. This explains why the 1-year average concentration is greater than the 95th percentile for 2010, it's skewed by the outlier. Excluding the maximum concentration measured at RICO from the 1-year average calculation for 2010 would result in a 1-year average concentration similar to 2009.
- Excluding the outlier, there is a decreasing trend in the statistical parameters representing the upper end of the concentrations measured at RICO between 2009 and 2012. All of the statistical parameters are at a minimum for 2012.
- Each of the statistical metrics shown in Figure 8-48 increased from 2012 to 2013, returning to levels similar to 2011.

- Aside from the outlier measured in 2010, the trends graph for ethylbenzene for RICO resembles the trends graph for benzene shown in Figure 8-46.

Figure 8-49. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at RICO



¹ A 1-year average is not presented due to low method completeness in 2010, 2011, and 2013.

Observations from Figure 8-49 for formaldehyde measurements collected at RICO include the following:

- The maximum formaldehyde concentration ($4.82 \mu\text{g}/\text{m}^3$) was measured at RICO in November 2008. The only other formaldehyde concentration greater than $4 \mu\text{g}/\text{m}^3$ was measured on August 26, 2013 ($4.38 \mu\text{g}/\text{m}^3$). Only three additional concentrations measured at RICO are greater than $3 \mu\text{g}/\text{m}^3$ (one each in 2008, 2010, and 2011).
- Because few 1-year average concentrations are shown, a distinct trend is hard to identify. However, the measurements appear to have an overall decreasing trend after 2010, based on the decreases shown for several of the other statistical parameters.
- The minimum and 5th percentiles decreased considerably from 2011 to 2012 and into 2013, similar to acetaldehyde. 2012 and 2013 account for nine of the 10 lowest concentrations (those less than $0.75 \mu\text{g}/\text{m}^3$) of formaldehyde measured at RICO.

8.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at each Colorado monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

8.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Colorado monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 8-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 8-6. Risk Approximations for the Colorado Monitoring Sites

Pollutant	Cancer URE (µg/m³) ⁻¹	Noncancer RfC (mg/m³)	# of Measured Detections vs. # of Samples	Annual Average (µg/m³)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Grand Junction, Colorado - GPCO						
Acetaldehyde	0.0000022	0.009	58/58	3.79 ± 0.57	8.33	0.42
Benzene	0.0000078	0.03	61/61	0.99 ± 0.16	7.73	0.03
1,3-Butadiene	0.00003	0.002	61/61	0.15 ± 0.03	4.46	0.07
Carbon Tetrachloride	0.000006	0.1	60/61	0.59 ± 0.03	3.51	0.01
1,2-Dichloroethane	0.000026	2.4	45/61	0.07 ± 0.01	1.71	<0.01
Ethylbenzene	0.0000025	1	61/61	0.49 ± 0.07	1.21	<0.01
Formaldehyde	0.000013	0.0098	58/58	6.44 ± 1.22	83.70	0.66
Hexachloro-1,3-butadiene	0.000022	0.09	13/61	0.02 ± 0.01	0.38	<0.01
Acenaphthene ^a	0.000088	--	56/56	8.05 ± 1.77	0.71	--
Benzo(a)pyrene ^a	0.00176	--	37/56	0.24 ± 0.10	0.42	--
Fluorene ^a	0.000088	--	54/56	6.88 ± 1.09	0.61	--
Naphthalene ^a	0.000034	0.003	56/56	136.93 ± 23.05	4.66	0.05
Battlement Mesa, Colorado - BMCO						
Acetaldehyde	0.0000022	0.009	27/28	0.46 ± 0.11	1.00	0.05
Benzene	0.0000078	0.03	54/55	1.26 ± 0.19	9.86	0.04
1,3-Butadiene	0.00003	0.002	3/55	<0.01 ± <0.01	0.11	<0.01
Ethylbenzene	0.0000025	1	50/55	0.14 ± 0.03	0.34	<0.01
Formaldehyde	0.000013	0.0098	28/28	0.82 ± 0.23	10.62	0.08
Silt, Colorado - BRCO						
Acetaldehyde	0.0000022	0.009	26/26	0.56 ± 0.12	1.23	0.06
Benzene	0.0000078	0.03	57/57	1.14 ± 0.20	8.92	0.04
Formaldehyde	0.000013	0.0098	26/26	0.87 ± 0.18	11.36	0.09

-- = A Cancer URE or Noncancer RfC is not available.

NA = Not available due to the criteria for calculating an annual average.

^a Average concentrations provided for the pollutants below the blue line for GPCO are presented in ng/m³ for ease of viewing.

Table 8-6. Risk Approximations for the Colorado Monitoring Sites (Continued)

Pollutant	Cancer URE (µg/m³) ⁻¹	Noncancer RfC (mg/m³)	# of Measured Detections vs. # of Samples	Annual Average (µg/m³)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Parachute, Colorado - PACO						
Acetaldehyde	0.0000022	0.009	25/26	0.76 ± 0.18	1.68	0.08
Benzene	0.0000078	0.03	49/52	1.96 ± 0.31	15.33	0.07
1,3-Butadiene	0.00003	0.002	9/52	0.01 ± 0.01	0.43	0.01
Formaldehyde	0.000013	0.0098	26/26	1.28 ± 0.25	16.63	0.13
Carbondale, Colorado - RFCO						
Acetaldehyde	0.0000022	0.009	27/27	0.58 ± 0.19	1.28	0.06
Benzene	0.0000078	0.03	23/29	0.57 ± 0.12	4.46	0.02
1,3-Butadiene	0.00003	0.002	6/29	0.02 ± 0.01	0.50	0.01
Formaldehyde	0.000013	0.0098	27/27	0.75 ± 0.21	9.76	0.08
Rifle, Colorado - RICO						
Acetaldehyde	0.0000022	0.009	25/25	NA	NA	NA
Benzene	0.0000078	0.03	23/29	1.52 ± 0.26	11.88	0.05
1,3-Butadiene	0.00003	0.002	52/57	0.11 ± 0.02	3.40	0.06
Ethylbenzene	0.0000025	1	57/57	0.35 ± 0.04	0.88	<0.01
Formaldehyde	0.000013	0.0098	25/25	NA	NA	NA

-- = A Cancer URE or Noncancer RfC is not available.

NA = Not available due to the criteria for calculating an annual average.

^a Average concentrations provided for the pollutants below the blue line for GPCO are presented in ng/m³ for ease of viewing.

Observations for GPCO from Table 8-6 include the following:

- Formaldehyde, acetaldehyde, and benzene have the highest annual average concentrations among GPCO's pollutants of interest.
- Formaldehyde has the highest cancer risk approximation for this site (83.70 in-a-million), followed by acetaldehyde (8.33 in-a-million), benzene (7.73 in-a-million), and naphthalene (4.66 in-a-million). GPCO's cancer risk approximation for formaldehyde is an order of magnitude greater than the cancer risk approximation for acetaldehyde and is the third highest cancer risk approximation calculated across the program for 2013.

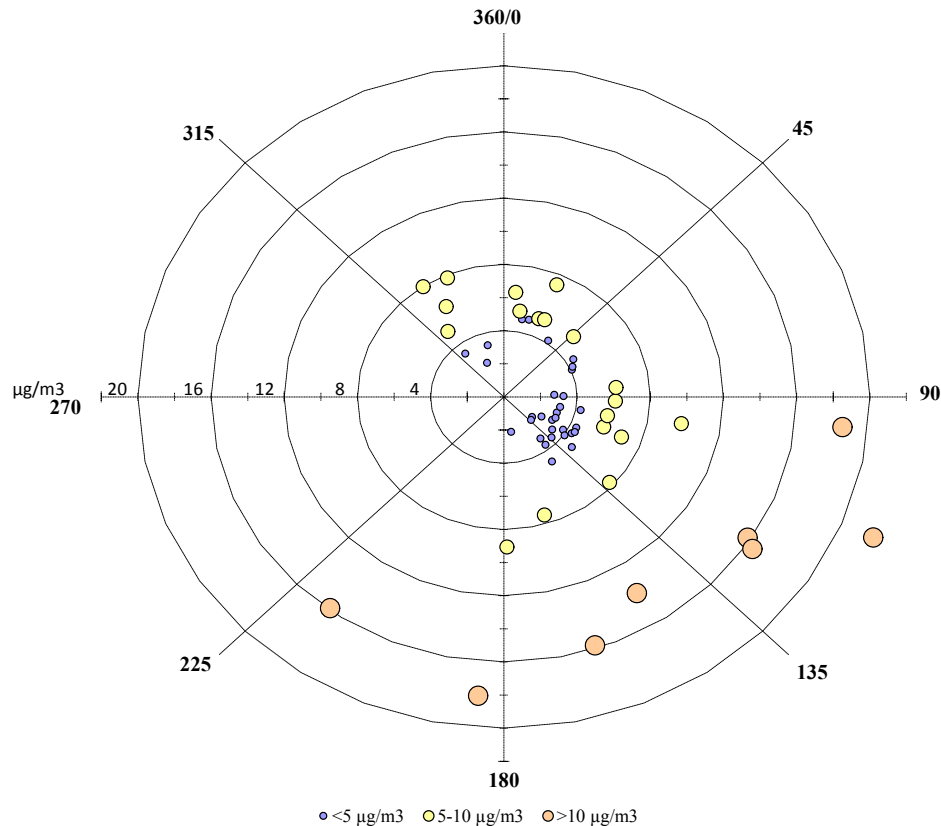
- None of the pollutants of interest for GPCO have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. Acetaldehyde and formaldehyde have the highest noncancer hazard approximations (0.66 and 0.42, respectively) among the pollutants of interest for GPCO. The noncancer hazard approximation for formaldehyde for GPCO is the second highest noncancer hazard approximation calculated across the program for 2013.

Observations for the Garfield County sites from Table 8-6 include the following:

- Benzene has the highest annual average concentration among the pollutants of interest for each Garfield County site, with the exception of RFCO. For RFCO, formaldehyde has the highest annual average concentration. Recall however, that annual averages could not be calculated for the carbonyl compounds for RICO.
- Formaldehyde and benzene have the highest cancer risk approximations for sites in which annual averages could be calculated. Formaldehyde's cancer risk approximations range from 9.76 in-a-million (RFCO) to 16.63 in-a-million (PACO). All of these are considerably less than the cancer risk approximation for formaldehyde for GPCO (83.70 in-a-million). Benzene's cancer risk approximations range from 4.46 in-a-million (RFCO) to 15.02 in-a-million (PACO). All of these benzene cancer risk approximations are slightly greater than the cancer risk approximation for benzene for GPCO (7.73 in-a-million), with the exception of RFCO.
- None of the noncancer hazard approximations calculated for the Garfield County sites are greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The highest noncancer hazard approximation was calculated for formaldehyde for PACO (0.13).
- Annual averages, and therefore cancer risk and noncancer hazard approximations, could not be calculated for acetaldehyde and formaldehyde for RICO.

For each of the site-specific pollutants of interest that have cancer risk approximations greater than 75 in-a-million and/or a noncancer hazard approximation greater than 1.0, a pollution rose was created to help identify the geographical area where the emissions sources of these pollutants may have originated. A pollution rose is a plot of the ambient concentration versus the wind speed and direction; high concentrations may be shown in relation to the direction of potential emissions sources. Additional information about this analysis is presented in Section 3.4.3.3. Figure 8-50 is GPCO's pollution rose for formaldehyde.

Figure 8-50. Pollution Rose for Formaldehyde Concentrations Measured at GPCO



Observations from Figure 8-50 include the following:

- The pollution rose shows that few formaldehyde concentrations are shown in relation with samples days with winds with a westerly component. Most of the formaldehyde concentrations are shown on the right-hand side of the wind rose, in relation to winds with an easterly component. This matches the wind observations shown on the sample day wind rose presented in Figure 8-10.
- The facility map in Figure 8-2 shows that most of the point sources are located on the right side of a diagonal line drawn northwest to southeast through the monitoring site location.
- The highest formaldehyde concentrations were all measured on sample days with winds with a southerly component, and most often from the southeast quadrant.
- If the formaldehyde concentrations are grouped by compass direction, the direction with the most concentrations is southeast, followed by east and south. If the formaldehyde concentrations are averaged by compass direction, the highest concentrations would be calculated for the southwest and south directions. The southwest direction only includes a single concentration; the average for the southerly direction includes five concentrations.

8.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 8-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 8-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 8-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 8-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 8-7. Table 8-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 8.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 8-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Colorado Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Grand Junction, Colorado (Mesa County) - GPCO					
Benzene	166.34	Formaldehyde	1.72E-03	Formaldehyde	83.70
Formaldehyde	131.94	Benzene	1.30E-03	Acetaldehyde	8.33
Ethylbenzene	55.92	1,3-Butadiene	4.48E-04	Benzene	7.73
Acetaldehyde	49.20	Naphthalene	2.34E-04	Naphthalene	4.66
1,3-Butadiene	14.93	POM, Group 2b	1.55E-04	1,3-Butadiene	4.46
Naphthalene	6.89	Ethylbenzene	1.40E-04	Carbon Tetrachloride	3.51
Dichloromethane	5.44	Acetaldehyde	1.08E-04	1,2-Dichloroethane	1.71
Tetrachloroethylene	1.86	POM, Group 2d	1.00E-04	Ethylbenzene	1.21
POM, Group 2b	1.76	POM, Group 5a	6.90E-05	Acenaphthene	0.71
POM, Group 2d	1.14	Arsenic, PM	3.36E-05	Fluorene	0.61
Battlement Mesa, Colorado (Garfield County) - BMCO					
Benzene	652.88	Formaldehyde	7.96E-03	Formaldehyde	10.62
Formaldehyde	612.56	Benzene	5.09E-03	Benzene	9.86
Acetaldehyde	112.59	1,3-Butadiene	3.78E-04	Acetaldehyde	1.00
Ethylbenzene	67.74	Acetaldehyde	2.48E-04	Ethylbenzene	0.34
1,3-Butadiene	12.62	Ethylbenzene	1.69E-04		
Naphthalene	4.78	Naphthalene	1.62E-04		
Tetrachloroethylene	1.01	POM, Group 2b	7.72E-05		
POM, Group 2b	0.88	POM, Group 2d	5.42E-05		
POM, Group 2d	0.62	POM, Group 5a	3.89E-05		
Dichloromethane	0.25	Arsenic, PM	3.28E-05		

Table 8-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Silt, Colorado (Garfield County) - BRCO					
Benzene	652.88	Formaldehyde	7.96E-03	Formaldehyde	11.36
Formaldehyde	612.56	Benzene	5.09E-03	Benzene	8.92
Acetaldehyde	112.59	1,3-Butadiene	3.78E-04	Acetaldehyde	1.23
Ethylbenzene	67.74	Acetaldehyde	2.48E-04		
1,3-Butadiene	12.62	Ethylbenzene	1.69E-04		
Naphthalene	4.78	Naphthalene	1.62E-04		
Tetrachloroethylene	1.01	POM, Group 2b	7.72E-05		
POM, Group 2b	0.88	POM, Group 2d	5.42E-05		
POM, Group 2d	0.62	POM, Group 5a	3.89E-05		
Dichloromethane	0.25	Arsenic, PM	3.28E-05		
Parachute, Colorado (Garfield County) - PACO					
Benzene	652.88	Formaldehyde	7.96E-03	Formaldehyde	16.63
Formaldehyde	612.56	Benzene	5.09E-03	Benzene	15.33
Acetaldehyde	112.59	1,3-Butadiene	3.78E-04	Acetaldehyde	1.68
Ethylbenzene	67.74	Acetaldehyde	2.48E-04	1,3-Butadiene	0.43
1,3-Butadiene	12.62	Ethylbenzene	1.69E-04		
Naphthalene	4.78	Naphthalene	1.62E-04		
Tetrachloroethylene	1.01	POM, Group 2b	7.72E-05		
POM, Group 2b	0.88	POM, Group 2d	5.42E-05		
POM, Group 2d	0.62	POM, Group 5a	3.89E-05		
Dichloromethane	0.25	Arsenic, PM	3.28E-05		

Table 8-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Carbondale, Colorado (Garfield County) - RFCO					
Benzene	652.88	Formaldehyde	7.96E-03	Formaldehyde	9.76
Formaldehyde	612.56	Benzene	5.09E-03	Benzene	4.46
Acetaldehyde	112.59	1,3-Butadiene	3.78E-04	Acetaldehyde	1.28
Ethylbenzene	67.74	Acetaldehyde	2.48E-04	1,3-Butadiene	0.50
1,3-Butadiene	12.62	Ethylbenzene	1.69E-04		
Naphthalene	4.78	Naphthalene	1.62E-04		
Tetrachloroethylene	1.01	POM, Group 2b	7.72E-05		
POM, Group 2b	0.88	POM, Group 2d	5.42E-05		
POM, Group 2d	0.62	POM, Group 5a	3.89E-05		
Dichloromethane	0.25	Arsenic, PM	3.28E-05		
Rifle, Colorado (Garfield County) - RICO					
Benzene	652.88	Formaldehyde	7.96E-03	Benzene	11.88
Formaldehyde	612.56	Benzene	5.09E-03	1,3-Butadiene	3.40
Acetaldehyde	112.59	1,3-Butadiene	3.78E-04	Ethylbenzene	0.88
Ethylbenzene	67.74	Acetaldehyde	2.48E-04		
1,3-Butadiene	12.62	Ethylbenzene	1.69E-04		
Naphthalene	4.78	Naphthalene	1.62E-04		
Tetrachloroethylene	1.01	POM, Group 2b	7.72E-05		
POM, Group 2b	0.88	POM, Group 2d	5.42E-05		
POM, Group 2d	0.62	POM, Group 5a	3.89E-05		
Dichloromethane	0.25	Arsenic, PM	3.28E-05		

Table 8-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Colorado Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Grand Junction, Colorado (Mesa County) - GPCO					
Toluene	381.86	Acrolein	550,555.59	Formaldehyde	0.66
Xylenes	274.58	Formaldehyde	13,463.29	Acetaldehyde	0.42
Benzene	166.34	1,3-Butadiene	7,464.46	1,3-Butadiene	0.07
Formaldehyde	131.94	Benzene	5,544.61	Naphthalene	0.05
Hexane	120.83	Acetaldehyde	5,466.88	Benzene	0.03
Methanol	102.01	Xylenes	2,745.81	Carbon Tetrachloride	0.01
Ethylbenzene	55.92	Naphthalene	2,298.28	Ethylbenzene	<0.01
Acetaldehyde	49.20	Antimony, PM	1,050.63	Hexachloro-1,3-butadiene	<0.01
Ethylene glycol	29.13	Lead, PM	767.25	1,2-Dichloroethane	<0.01
1,3-Butadiene	14.93	Arsenic, PM	521.58		
Battlement Mesa, Colorado (Garfield County) - BMCO					
Toluene	1,190.11	Acrolein	3,464,518.24	Formaldehyde	0.08
Xylenes	730.99	Formaldehyde	62,505.94	Acetaldehyde	0.05
Benzene	652.88	Benzene	21,762.81	Benzene	0.04
Methanol	623.52	Acetaldehyde	12,509.99	1,3-Butadiene	<0.01
Formaldehyde	612.56	Xylenes	7,309.95	Ethylbenzene	<0.01
Hexane	169.35	1,3-Butadiene	6,308.09		
Acetaldehyde	112.59	Naphthalene	1,592.72		
Acrolein	69.29	Propionaldehyde	567.82		
Ethylbenzene	67.74	Cadmium, PM	526.47		
1,3-Butadiene	12.62	Arsenic, PM	508.98		

Table 8-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Silt, Colorado (Garfield County) - BRCO					
Toluene	1,190.11	Acrolein	3,464,518.24	Formaldehyde	0.09
Xylenes	730.99	Formaldehyde	62,505.94	Acetaldehyde	0.06
Benzene	652.88	Benzene	21,762.81	Benzene	0.04
Methanol	623.52	Acetaldehyde	12,509.99		
Formaldehyde	612.56	Xylenes	7,309.95		
Hexane	169.35	1,3-Butadiene	6,308.09		
Acetaldehyde	112.59	Naphthalene	1,592.72		
Acrolein	69.29	Propionaldehyde	567.82		
Ethylbenzene	67.74	Cadmium, PM	526.47		
1,3-Butadiene	12.62	Arsenic, PM	508.98		
Parachute, Colorado (Garfield County) - PACO					
Toluene	1,190.11	Acrolein	3,464,518.24	Formaldehyde	0.13
Xylenes	730.99	Formaldehyde	62,505.94	Acetaldehyde	0.08
Benzene	652.88	Benzene	21,762.81	Benzene	0.07
Methanol	623.52	Acetaldehyde	12,509.99	1,3-Butadiene	0.01
Formaldehyde	612.56	Xylenes	7,309.95		
Hexane	169.35	1,3-Butadiene	6,308.09		
Acetaldehyde	112.59	Naphthalene	1,592.72		
Acrolein	69.29	Propionaldehyde	567.82		
Ethylbenzene	67.74	Cadmium, PM	526.47		
1,3-Butadiene	12.62	Arsenic, PM	508.98		

Table 8-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Carbondale, Colorado (Garfield County) - RFCO					
Toluene	1,190.11	Acrolein	3,464,518.24	Formaldehyde	0.08
Xylenes	730.99	Formaldehyde	62,505.94	Acetaldehyde	0.06
Benzene	652.88	Benzene	21,762.81	Benzene	0.02
Methanol	623.52	Acetaldehyde	12,509.99	1,3-Butadiene	0.01
Formaldehyde	612.56	Xylenes	7,309.95		
Hexane	169.35	1,3-Butadiene	6,308.09		
Acetaldehyde	112.59	Naphthalene	1,592.72		
Acrolein	69.29	Propionaldehyde	567.82		
Ethylbenzene	67.74	Cadmium, PM	526.47		
1,3-Butadiene	12.62	Arsenic, PM	508.98		
Rifle, Colorado (Garfield County) - RICO					
Toluene	1,190.11	Acrolein	3,464,518.24	1,3-Butadiene	0.06
Xylenes	730.99	Formaldehyde	62,505.94	Benzene	0.05
Benzene	652.88	Benzene	21,762.81	Ethylbenzene	<0.01
Methanol	623.52	Acetaldehyde	12,509.99		
Formaldehyde	612.56	Xylenes	7,309.95		
Hexane	169.35	1,3-Butadiene	6,308.09		
Acetaldehyde	112.59	Naphthalene	1,592.72		
Acrolein	69.29	Propionaldehyde	567.82		
Ethylbenzene	67.74	Cadmium, PM	526.47		
1,3-Butadiene	12.62	Arsenic, PM	508.98		

Observations from Table 8-7 include the following:

- The 10 highest emitted pollutants with cancer UREs in Mesa County are the highest emitted pollutants in Garfield County, although not necessarily in the same order. Benzene and formaldehyde top both lists, although the emissions are more than three times higher for Garfield County than Mesa County.
- The two pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde and benzene for both Mesa and Garfield Counties. These two counties have the same pollutants listed for the pollutants with the highest toxicity-weighted emissions.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions in Mesa County; the same eight pollutants have the highest emitted pollutants and highest toxicity-weighted emissions for Garfield County.
- For GPCO, eight of the 10 pollutants with the highest cancer risk approximations also appear on both emissions-based lists for Mesa County. POM, Group 2b, which is the ninth highest emitted “pollutant” in Mesa County and ranks fifth for toxicity-weighted emissions, includes several PAHs sampled for at GPCO including acenaphthene and fluorene, which have the ninth and tenth highest cancer risk approximations, respectively, for GPCO. Carbon tetrachloride and 1,2-dichloroethane do not appear on either emissions-based list for Mesa County, although they have the sixth and seventh highest cancer risk approximations, respectively, for GPCO.
- Each of the pollutants of interest identified for the Garfield County sites appear on both emissions-based lists in Table 8-7.

Observations from Table 8-8 include the following:

- Toluene is the highest emitted pollutant with a noncancer RfC in both Mesa and Garfield Counties, although the emissions are considerably higher in Garfield County. These two counties have an additional eight pollutants in common on their lists of highest emitted pollutants with noncancer RfCs.
- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties is acrolein. Although acrolein was sampled for at GPCO, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. Acrolein is not a target analyte for the SNMOC method. Although acrolein has the highest toxicity-weighted emissions for all but one county with an NMP site, rarely does it appear among the highest emitted pollutants. Garfield County is the only county with an NMP site for which acrolein ranks among the highest emitted. A similar observation was made in the 2011 and 2012 NMP reports.
- Five of the highest emitted pollutants in Mesa County also have the highest toxicity-weighted emissions. Six of the 10 highest emitted pollutants in Garfield County

(including acrolein) also have the highest toxicity-weighted emissions. Toluene, the highest emitted pollutant for both counties, is not among those with the highest toxicity-weighted emissions. Several metals appear near the bottom of each toxicity-weighted emissions list.

- Formaldehyde, acetaldehyde, benzene, and 1,3-butadiene appear on all three lists for GPCO. Naphthalene appears among the pollutants with the highest noncancer hazard approximations and highest toxicity-weighted emissions, but is not among the highest emitted pollutants with a noncancer RfC in Mesa County. Ethylbenzene appears among the pollutants with the highest noncancer hazard approximations for GPCO and highest emissions in Mesa County, but is not among those with the highest toxicity-weighted emissions.
- Each of the pollutants of interest identified for the Garfield County sites appear on both emissions-based lists in Table 8-8, with one exception. Ethylbenzene is a pollutant of interest for RICO and BMCO. Ethylbenzene appears among the pollutants with the highest emissions in Garfield County, but is not among those with the highest toxicity-weighted emissions.

8.6 Summary of the 2013 Monitoring Data for the Colorado Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *Fifteen pollutants failed screens for GPCO. The number of pollutants failing screens for the Garfield County sites ranged from four to five.*
- ❖ *Formaldehyde and acetaldehyde have highest annual average concentrations for GPCO; these were the only pollutants with annual average concentrations greater than 1 $\mu\text{g}/\text{m}^3$. Benzene had the highest annual average concentration for each of the Garfield County sites, except RFCO, where formaldehyde was highest.*
- ❖ *GPCO has the second highest annual average concentrations of acetaldehyde, formaldehyde, and naphthalene among all NMP sites sampling these pollutants. Each of the Garfield County sites are among the sites with the highest annual average concentrations of benzene except RFCO.*
- ❖ *Benzene concentrations at GPCO have an overall decreasing trend across the years of sampling, while acetaldehyde concentrations have been increasing in recent years at this site. In addition, the detection rate of 1,2-dichloroethane at GPCO has been increasing steadily over the last few years of sampling.*
- ❖ *Formaldehyde has the highest cancer risk approximation of the pollutants of interest for GPCO as well as four of the five Garfield County sites. None of the pollutants of interest for the Colorado monitoring sites have noncancer hazard approximations greater than an HQ of 1.0.*

9.0 Site in the District of Columbia

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Washington, D.C., and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

9.1 Site Characterization

This section characterizes the Washington, D.C. monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

Figure 9-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 9-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 9-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 9-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 9-1. Washington, D.C. (WADC) Monitoring Site

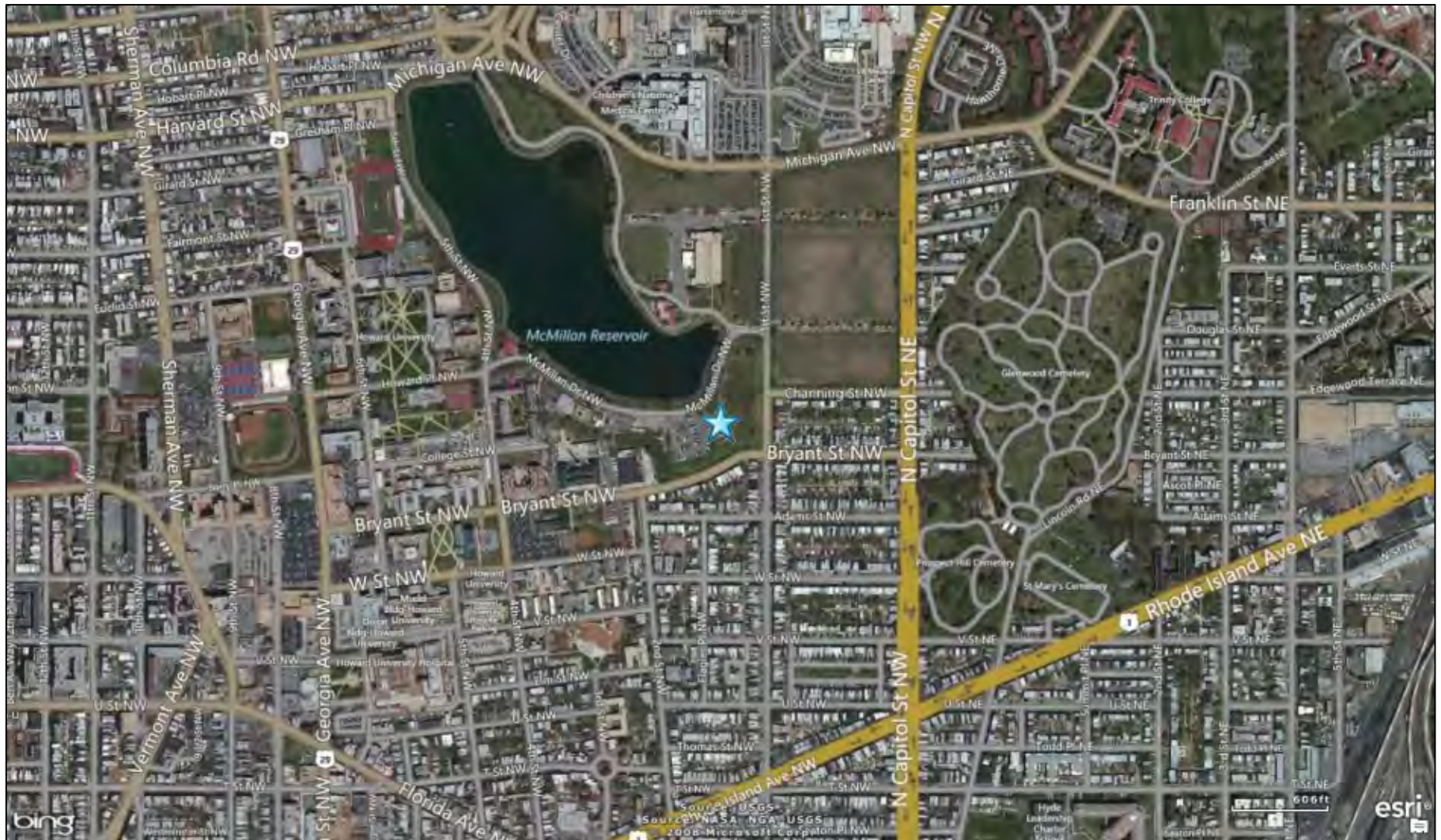


Figure 9-2. NEI Point Sources Located Within 10 Miles of WADC

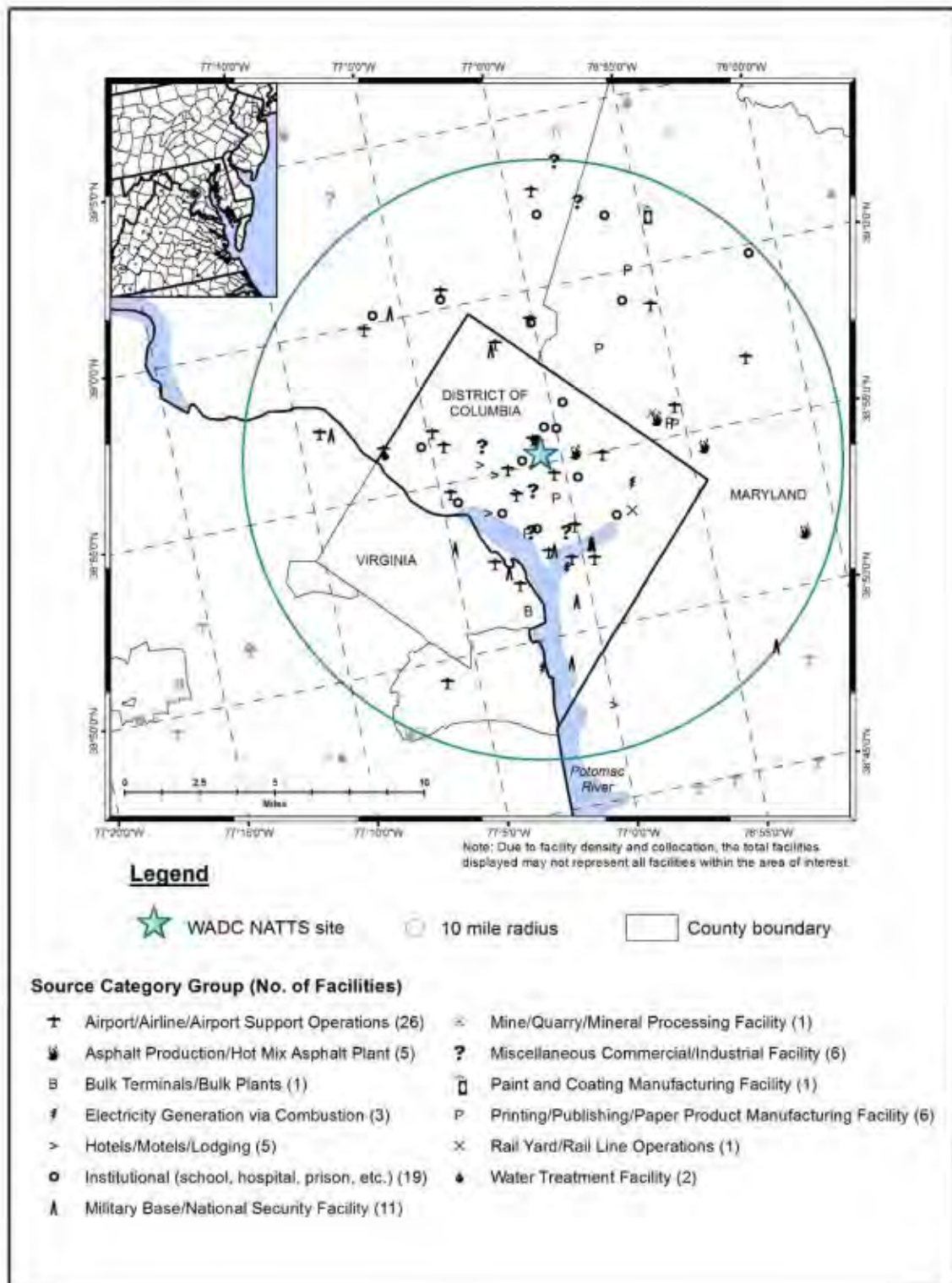


Table 9-1. Geographical Information for the Washington, D.C. Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>WADC</i>	11-001-0043	Washington	District Of Columbia	Washington-Arlington-Alexandria, DC-VA-MD-WV	38.921847, -77.013178	Commercial	Urban/City Center	Arsenic, Lead, CO, VOCs, SO ₂ , NO _y , NO, NO ₂ , NO _x , PAMS, Carbonyl compounds, O ₃ , Meteorological parameters, PM ₁₀ , PM ₁₀ Speciation, Size fractionated particulate, Black carbon, PM Coarse, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation, SNMOC

¹Data for additional pollutants are reported to AQS for WADC (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

Figure 9-1 shows that the WADC monitoring site is located in an open field at the southeast end of the McMillan Water Reservoir in Washington, D.C. It is also located near several heavily traveled roadways. The site is located in a commercial area, and is surrounded by a hospital, a cemetery, and a university. As Figure 9-2 shows, WADC is surrounded by a number of sources, many of which are included in three sources categories: 1) the airport and airport support operations source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; 2) the institutions category, which includes hospital, schools, and prisons, etc.; and 3) the military bases and national security facilities. The closest sources to WADC are a wastewater treatment facility, hospitals, and heliports at hospitals.

Table 9-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Washington D.C. monitoring site. Table 9-2 includes both county-level population and vehicle registration information. Table 9-2 also contains traffic volume information for WADC, as well as the location for which the traffic volume was obtained. Additionally, Table 9-2 presents the daily VMT for the District of Columbia.

Table 9-2. Population, Motor Vehicle, and Traffic Information for the Washington, D.C. Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
WADC	District of Columbia	646,449	322,350	8,700	1st St between W St and V St	9,786,301

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2012 data (FHWA, 2014)

³AADT reflects 2011 data (DC DOT, 2012)

⁴County-level VMT reflects 2012 data (FHWA, 2013b)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 9-2 include the following:

- The District's population is in the middle of the range compared to other counties with NMP sites. The District-level vehicle registration is also in the middle of the range compared to other counties with NMP sites.
- The traffic volume experienced near WADC is in the bottom third compared to other NMP sites. The traffic volume provided is for 1st Street, the closest roadway east of the monitoring site, between W Street and V Street, three to four blocks south of the site.

- The district-level VMT is nearly 10 million miles and is in the middle of the range compared to VMTs for other counties with NMP sites.

9.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Washington, D.C. on sample days, as well as over the course of the year.

9.2.1 Climate Summary

Located on the Potomac River that divides Virginia and Maryland, Washington, D.C. experiences all four seasons, although its weather is somewhat variable. Summers are warm and often humid, as southerly winds prevail. Summertime temperatures can be accentuated by the urban heat island effect. Winters are typical of the Mid-Atlantic region, where cool, blustery air masses are common followed by a fairly quick return to mild temperatures. Winds out of the northwest are prevalent in the period from December to March while southerly wind prevail throughout the rest of the year. Precipitation is fairly evenly distributed across the seasons (Wood, 2004).

9.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Washington, D.C. monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station to WADC is located at Ronald Reagan Washington National Airport (WBAN 13743). Additional information about the Reagan National Airport weather station, such as the distance between the site and the weather station, is provided in Table 9-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 9-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 9-3 is the 95 percent confidence interval for each parameter. As shown in Table 9-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year near WADC.

Table 9-3. Average Meteorological Conditions near the Washington, D.C. Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Washington, D.C. - WADC									
Ronald Reagan Washington National Airport 13743 (38.85, -77.03)	5.2 miles 193° (SSW)	Sample Days (61)	66.7 ± 4.7	58.6 ± 4.5	44.0 ± 5.1	51.6 ± 4.2	61.0 ± 3.5	1019.2 ± 1.7	7.5 ± 0.7
		2013	66.2 ± 1.8	58.5 ± 1.7	44.2 ± 1.9	51.6 ± 1.6	61.8 ± 1.4	1018.6 ± 0.7	7.2 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

9.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at Ronald Reagan Washington National Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 9-3 presents a map showing the distance between the weather station and WADC, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 9-3 also presents three different wind roses for the WADC monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 9-3 for WADC include the following:

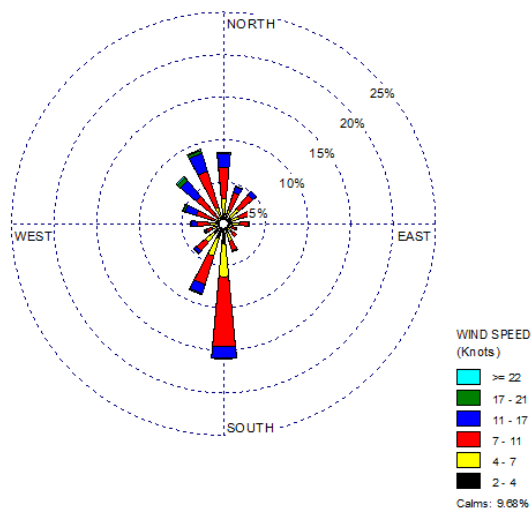
- The weather station at Reagan National Airport is located 5.2 miles south-southwest of WADC. Between WADC and Reagan National Airport is much of the city of Washington and the Potomac River.
- Historically, southerly to south-southwesterly winds account for approximately 25 percent of wind observations near WADC, while northwesterly to northerly winds account for another 25 percent of observations. Calm winds (those less than or equal to 2 knots) were observed for just less than 10 percent of the hourly measurements.
- The wind patterns on the full-year wind rose are similar to the wind patterns shown on the historical wind rose, with southerly and south-southwesterly winds accounting for nearly 30 percent of the wind observations for 2013.
- The sample day wind patterns resemble those on the full-year wind rose, although there are some differences. Southerly winds account for an even higher percentage of wind observations on sample days in 2013. Winds from the north-northwest also account for a higher percentage of wind observations on sample days. Fewer calm winds were observed on sample days in 2013, accounting for less than 8 percent of observations. Overall, though, the similarities in the three wind roses indicate that wind patterns in 2013 were similar to what is expected climatologically near this site.

Figure 9-3. Wind Roses for the Ronald Reagan Washington National Airport Weather Station near WADC

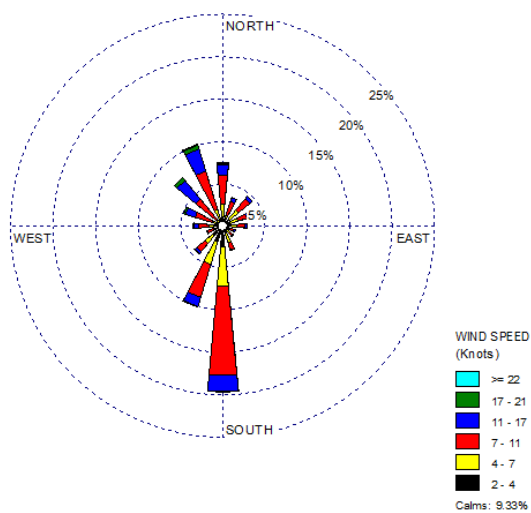
Location of WADC and Weather Station



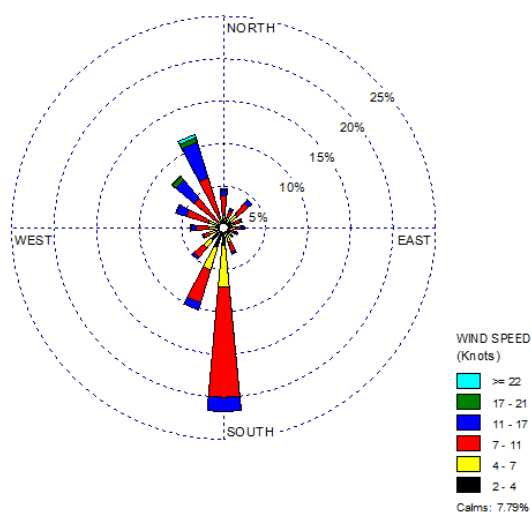
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



9.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the Washington, D.C. monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 9-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 9-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Hexavalent chromium and PAHs were sampled for at WADC. Note that hexavalent chromium sampling was discontinued at WADC at the end of June 2013.

Table 9-4. Risk-Based Screening Results for the Washington, D.C. Monitoring Site

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Washington, D.C. - WADC						
Naphthalene	0.029	59	60	98.33	96.72	96.72
Acenaphthylene	0.011	1	25	4.00	1.64	98.36
Hexavalent Chromium	0.000083	1	8	12.50	1.64	100.00
Total		61	93	65.59		

Observations from Table 9-4 include the following:

- Three pollutants failed screens for WADC: naphthalene, acenaphthylene, and hexavalent chromium.
- While naphthalene failed 98 percent of its total screens, acenaphthylene and hexavalent chromium failed a single screen each.
- Naphthalene accounted for nearly 97 percent of the total failed screens for WADC; thus, naphthalene is WADC’s only pollutant of interest.

9.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Washington, D.C. monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at WADC are provided in Appendices M and O.

9.4.1 2013 Concentration Averages

Quarterly and annual average concentrations were calculated for the pollutants of interest for the Washington, D.C. monitoring site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for WADC are presented in Table 9-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 9-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Washington, D.C. Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
Washington, D.C. - WADC						
Naphthalene	60/60	68.61 ± 20.37	100.85 ± 32.72	74.59 ± 22.45	88.51 ± 33.64	83.14 ± 13.50

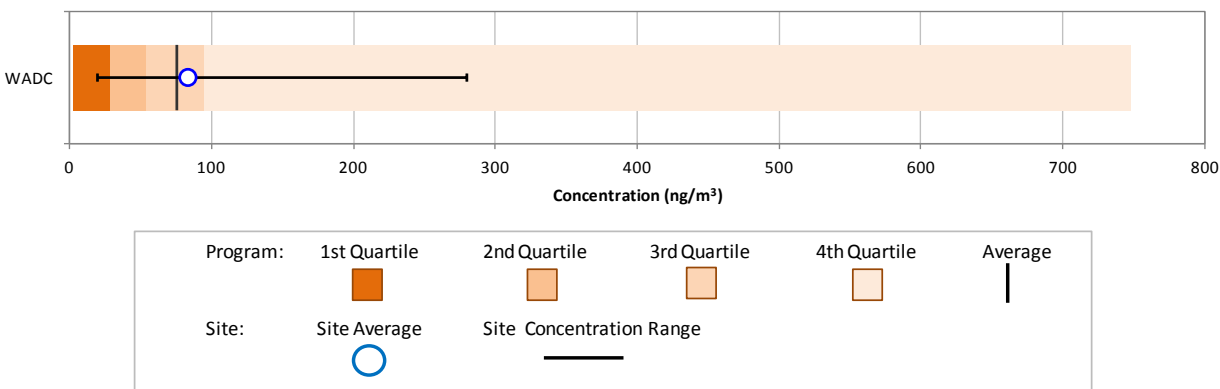
Observations for WADC from Table 9-5 include the following:

- Naphthalene was detected in every valid PAH sample collected at WADC.
- Concentrations of naphthalene measured at WADC range from 18.9 ng/m³ to 280 ng/m³.
- The second quarter average concentration of naphthalene is higher than the other quarterly averages shown in Table 9-5, and the associated confidence interval indicates that there is considerably variability in the measurements. The fourth quarter average concentration has a similar confidence interval. The two highest concentrations of naphthalene measured at WADC, 280 ng/m³ measured in October and 274 ng/m³ measured in May, are both more than 100 ng/m³ higher than the third highest naphthalene concentration measured at WADC (173 ng/m³ measured in January). Of the 18 naphthalene concentrations greater than 100 ng/m³ measured at WADC, the highest number of these were measured during the second quarter of 2013 (6), followed by the fourth quarter (5).
- As shown in Table 4-11, WADC has the ninth highest annual average concentration of naphthalene compared to other NMP sites sampling PAHs.

9.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for the site-specific pollutants of interest, where applicable. Thus, a box plot was created for naphthalene for WADC. Figure 9-4 overlays the site's minimum, annual average, and maximum naphthalene concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 9-4. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figure 9-4 include the following:

- The maximum naphthalene concentration measured at WADC is considerably less than the program-level maximum concentration. The annual average concentration of naphthalene for WADC ($83.14 \pm 13.50 \text{ ng/m}^3$) is greater than the program-level average concentration (75.26 ng/m^3) but less than the program-level third quartile (94.65 ng/m^3).

9.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. WADC has sampled PAHs under the NMP since mid-2008. Thus, Figure 9-5 presents the 1-year statistical metrics for naphthalene for WADC. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

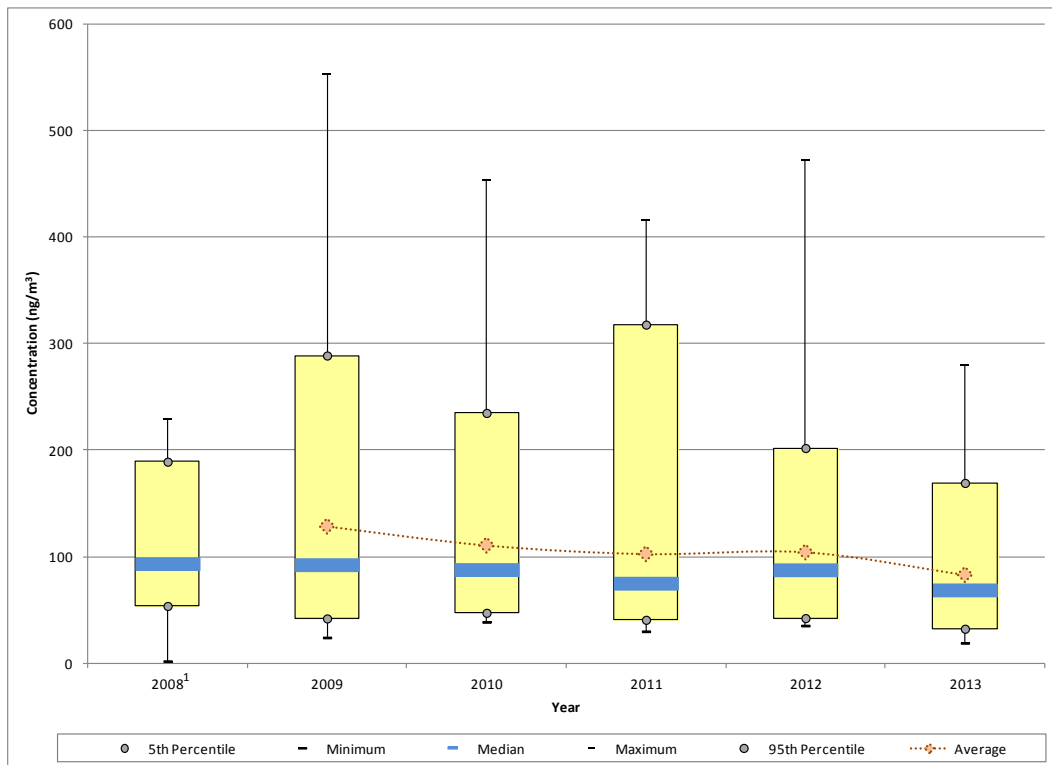
Observations from Figure 9-5 for naphthalene measurements collected at WADC include the following:

- WADC began sampling PAHs under the NMP in late June 2008.
- The maximum naphthalene concentration shown was measured in 2009 and is the only concentration greater than 500 ng/m^3 measured at this site (553 ng/m^3). Concentrations greater than 400 ng/m^3 have been measured in each year of sampling except 2008 (which included only half a year's worth of samples) and 2013.
- The 1-year average concentrations exhibit an overall decreasing trend between 2009 and 2013. 2013 is the first year with a 1-year average concentration less than

100 ng/m³. The median concentration also has an overall decreasing trend, although the median increased from 2011 to 2012 before exhibiting further decreases from 2012 to 2013. The median concentration is less than 100 ng/m³ for each year shown in Figure 9-5, and is at a minimum for 2013 (68.70 ng/m³).

- The difference between the 5th and 95th percentiles is at a minimum for 2013 (excluding 2008), indicating that the majority of concentrations measured fell within a tighter range of measurements. A similar observation was made for 2012 in the 2012 NMP report.

Figure 9-5. Yearly Statistical Metrics for Naphthalene Concentrations Measured at WADC



¹ A 1-year average is not presented because sampling under the NMP did not begin until late June 2008.

9.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the WADC monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

9.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for WADC and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard

approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 9-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 9-6. Risk Approximations for the Washington, D.C. Monitoring Site

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Washington, D.C. - WADC						
Naphthalene	0.000034	0.003	60/60	83.14 ± 13.50	2.83	0.03

Observations for WADC from Table 9-6 include the following:

- As discussed in Section 9.4.1, the annual average concentration of naphthalene for WADC is the ninth highest annual average concentration compared to other NMP sites sampling this pollutant.
- The cancer risk approximation for naphthalene is greater than 1.0 in-a-million (2.83 in-a-million).
- The noncancer hazard approximation for naphthalene is significantly less than 1.0, indicating that no adverse noncancer health effects are expected from this individual pollutant.

9.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, Tables 9-7 and 9-8 present an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 9-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 9-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 9-7 provides the cancer risk approximation (in-a-million) for the pollutant of interest for WADC, as presented in Table 9-6. The emissions, toxicity-weighted emissions, and cancer risk

approximations are shown in descending order in Table 9-7. Table 9-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 9.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 9-7 include the following:

- Benzene and formaldehyde are the highest emitted pollutants with cancer UREs in the District of Columbia. Formaldehyde and benzene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs).
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions.
- Naphthalene is the only pollutant of interest for WADC. This pollutant appears on both emissions-based lists. Naphthalene is the seventh highest emitted pollutant with a cancer URE in the District of Columbia and has the fourth highest toxicity-weighted emissions (of the pollutants with cancer UREs).
- Several POM Groups are among the highest emitted “pollutants” in the District and/or rank among the pollutants with the highest toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at WADC including acenaphthylene, which failed a single screen for WADC. POM, Group 2d includes several PAHs sampled for at WADC, such as anthracene and phenanthrene, but none of these failed screens. POM, Group 5a includes benzo(a)pyrene, which did not fail screens for WADC.

Table 9-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Washington, D.C. Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Washington, D.C. (District of Columbia) - WADC					
Benzene	110.18	Formaldehyde	1.21E-03	Naphthalene	2.83
Formaldehyde	92.82	Benzene	8.59E-04		
Acetaldehyde	52.06	1,3-Butadiene	5.06E-04		
Ethylbenzene	51.75	Naphthalene	2.78E-04		
Tetrachloroethylene	18.70	POM, Group 2b	2.21E-04		
1,3-Butadiene	16.86	Nickel, PM	1.51E-04		
Naphthalene	8.18	POM, Group 2d	1.50E-04		
POM, Group 2b	2.51	Ethylbenzene	1.29E-04		
POM, Group 2d	1.71	Acetaldehyde	1.15E-04		
Dichloromethane	0.82	POM, Group 5a	1.11E-04		

Table 9-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Washington, D.C. Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Washington, D.C. (District of Columbia) - WADC					
Toluene	363.94	Acrolein	229,665.41	Naphthalene	0.03
Methanol	352.82	Formaldehyde	9,471.05		
Hexane	217.66	1,3-Butadiene	8,432.47		
Xylenes	213.36	Acetaldehyde	5,784.35		
Ethylene glycol	123.11	Benzene	3,672.70		
Benzene	110.18	Nickel, PM	3,505.21		
Formaldehyde	92.82	Chlorine	3,176.67		
Acetaldehyde	52.06	Naphthalene	2,725.10		
Ethylbenzene	51.75	Xylenes	2,133.58		
Methyl isobutyl ketone	26.88	Arsenic, PM	1,691.85		

Observations from Table 9-8 include the following:

- Toluene, methanol, and hexane are the highest emitted pollutants with noncancer RfCs in the District of Columbia.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and 1,3-butadiene.
- Four of the highest emitted pollutants in the District of Columbia also have the highest toxicity-weighted emissions.
- Naphthalene has the eighth highest toxicity-weighted emissions but is not one of the 10 highest emitted pollutants (of the pollutants with noncancer RfCs).
- None of the other pollutants sampled for at WADC under the NMP appear in Table 9-8.

9.6 Summary of the 2013 Monitoring Data for WADC

Results from several of the data treatments described in this section include the following:

- ❖ *Although three PAHs failed screens, naphthalene failed the majority of screens and was therefore the only pollutant of interest identified via the risk screening process.*
- ❖ *The annual average concentration of naphthalene for WADC ranks ninth among NMP sites sampling this pollutant.*
- ❖ *Concentrations of naphthalene have an overall decreasing trend at WADC.*

10.0 Sites in Florida

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Florida, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

10.1 Site Characterization

This section characterizes the Florida monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The six Florida sites are located in three different urban areas. Three sites (AZFL, SKFL, and SYFL) are located in the Tampa-St. Petersburg-Clearwater, Florida CBSA. ORFL and PAFL are located in the Orlando-Kissimmee-Sanford, Florida CBSA. Another site, WPFL, is located in the Miami-Ft. Lauderdale-West Palm Beach, Florida CBSA. Figures 10-1 and 10-2 are composite satellite images retrieved from ArcGIS Explorer showing the St. Petersburg area monitoring sites and their immediate surroundings. Figure 10-3 identifies nearby point source emissions locations that surround these two sites by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 10-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile boundaries are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Figures 10-4 through 10-10 are the composite satellite images and emissions sources maps for the Tampa site, the two sites in the Orlando area, and the site in Belle Glade. Table 10-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 10-1. St. Petersburg, Florida (AZFL) Monitoring Site

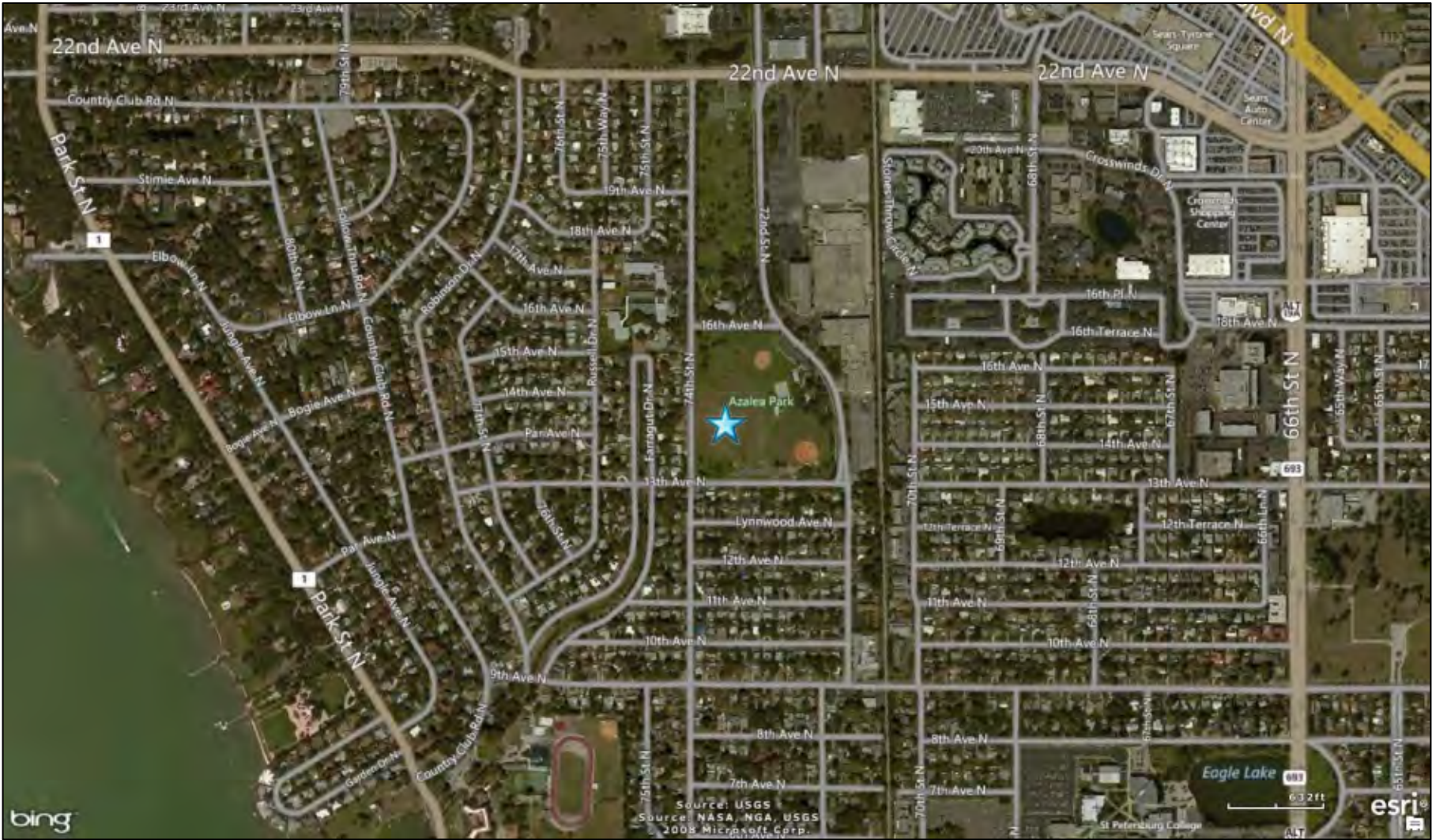


Figure 10-2. Pinellas Park, Florida (SKFL) Monitoring Site

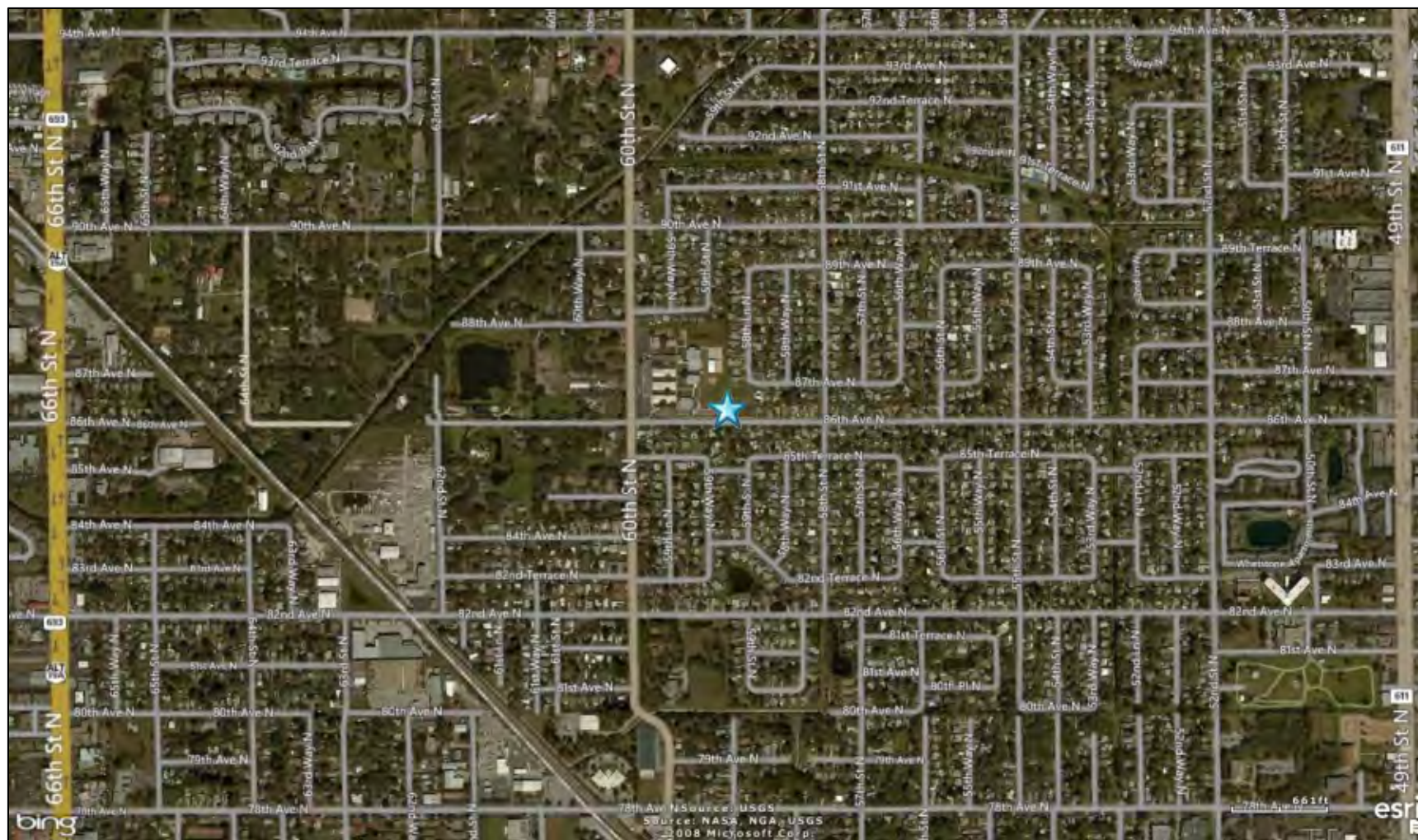


Figure 10-3. NEI Point Sources Located Within 10 Miles of AZFL and SKFL

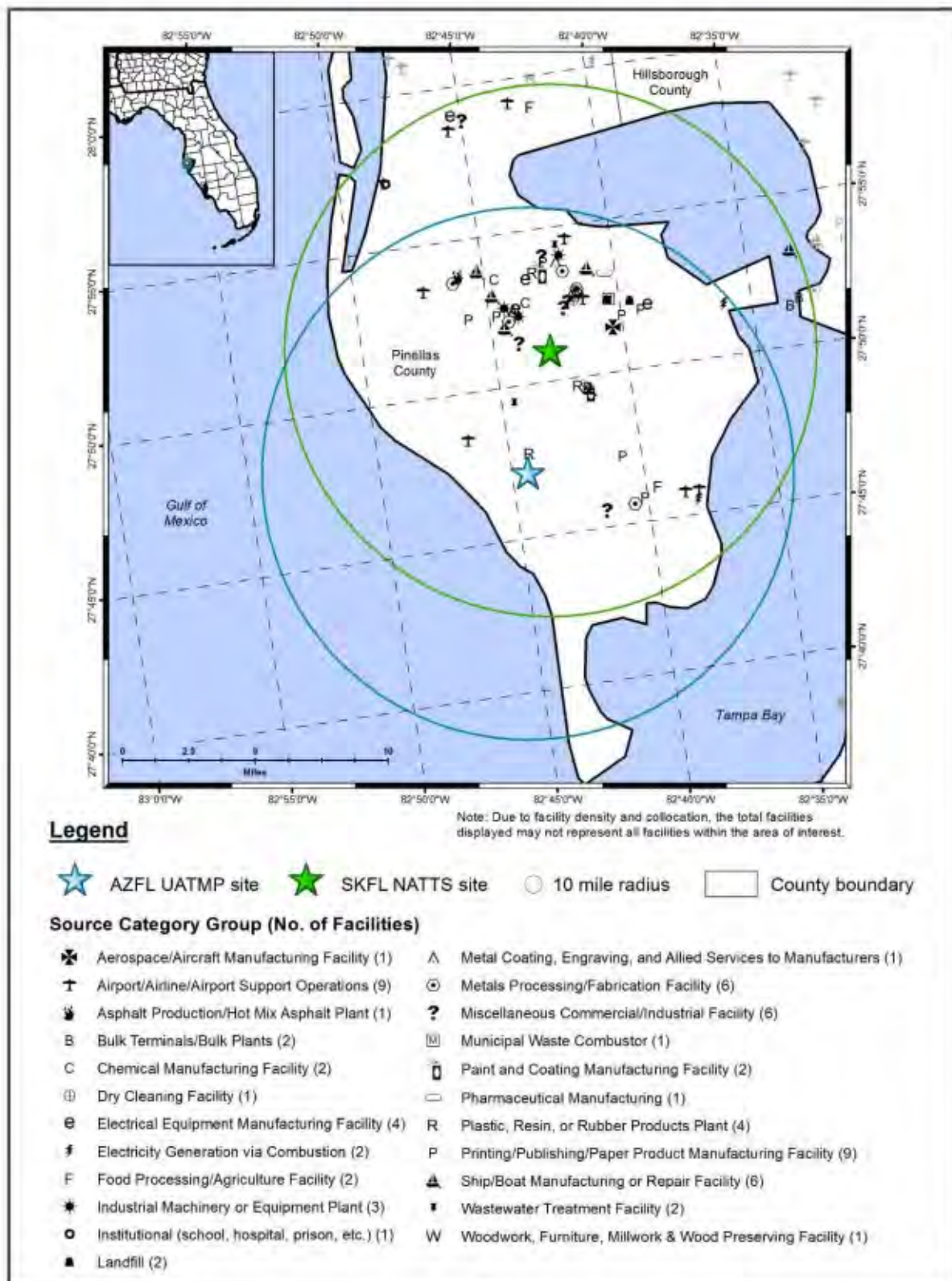


Figure 10-4. Valrico, Florida (SYFL) Monitoring Site

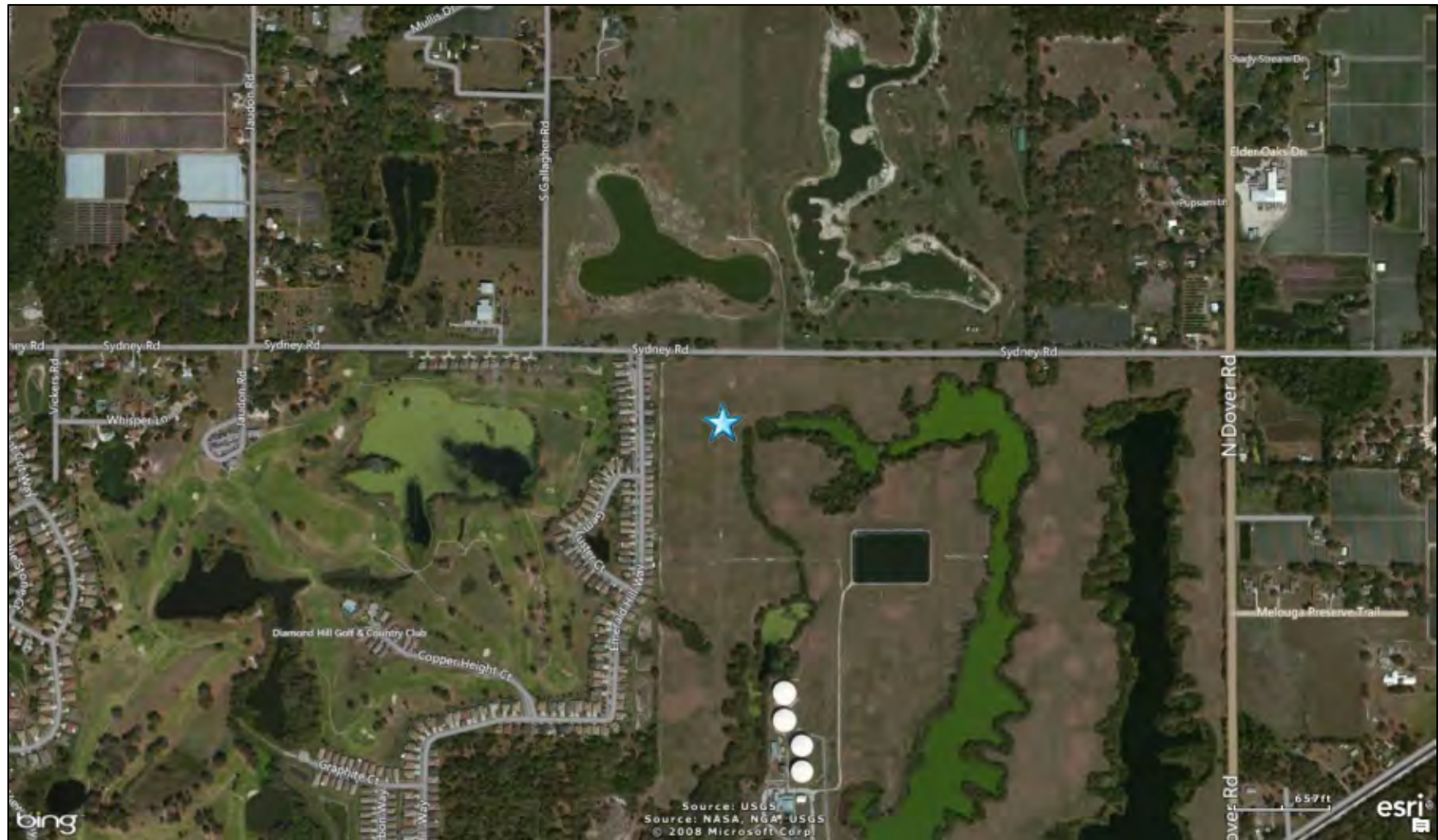
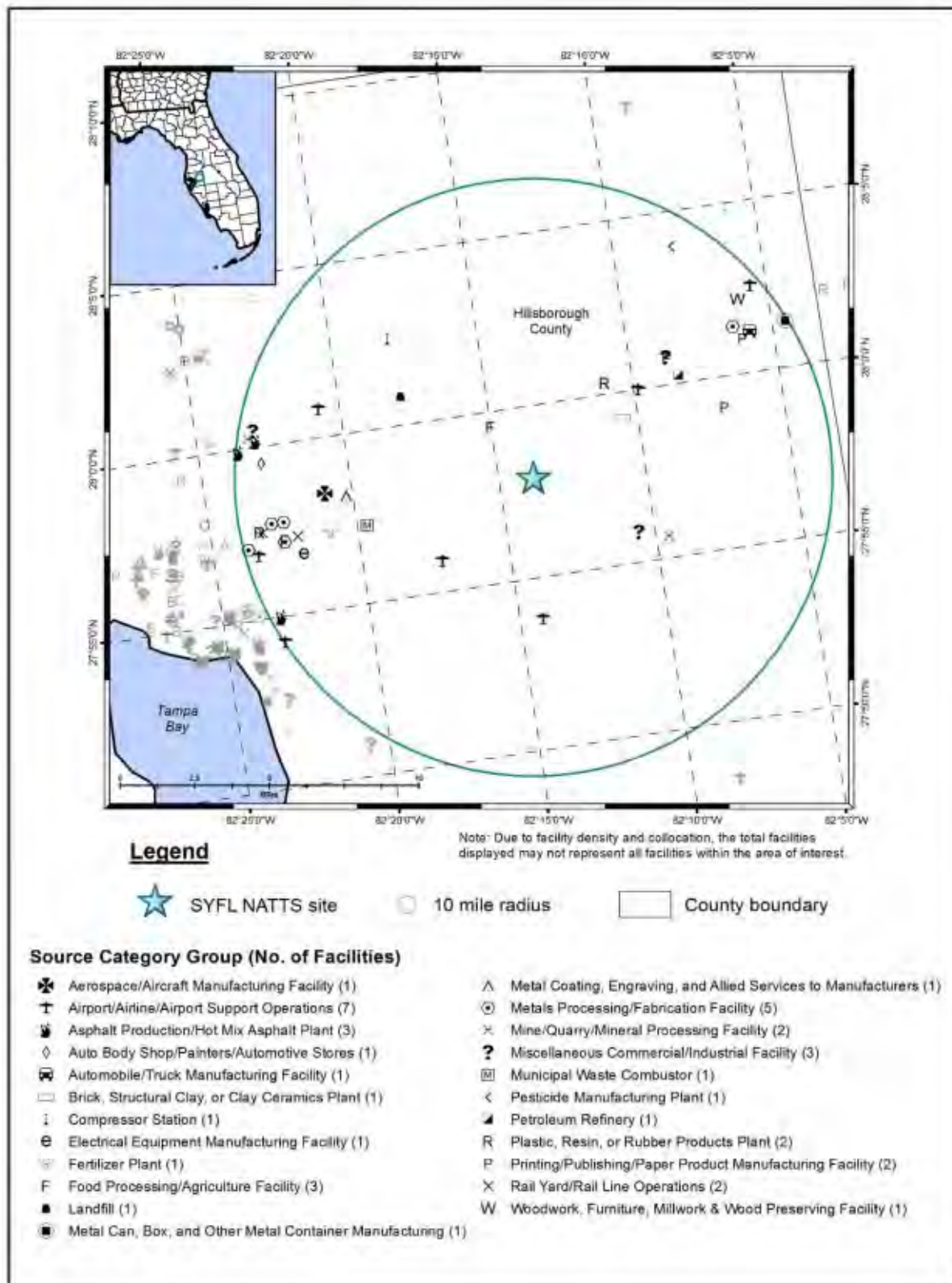


Figure 10-5. NEI Point Sources Located Within 10 Miles of SYFL



10-7



Figure 10-7. Orlando, Florida (PAFL) Monitoring Site

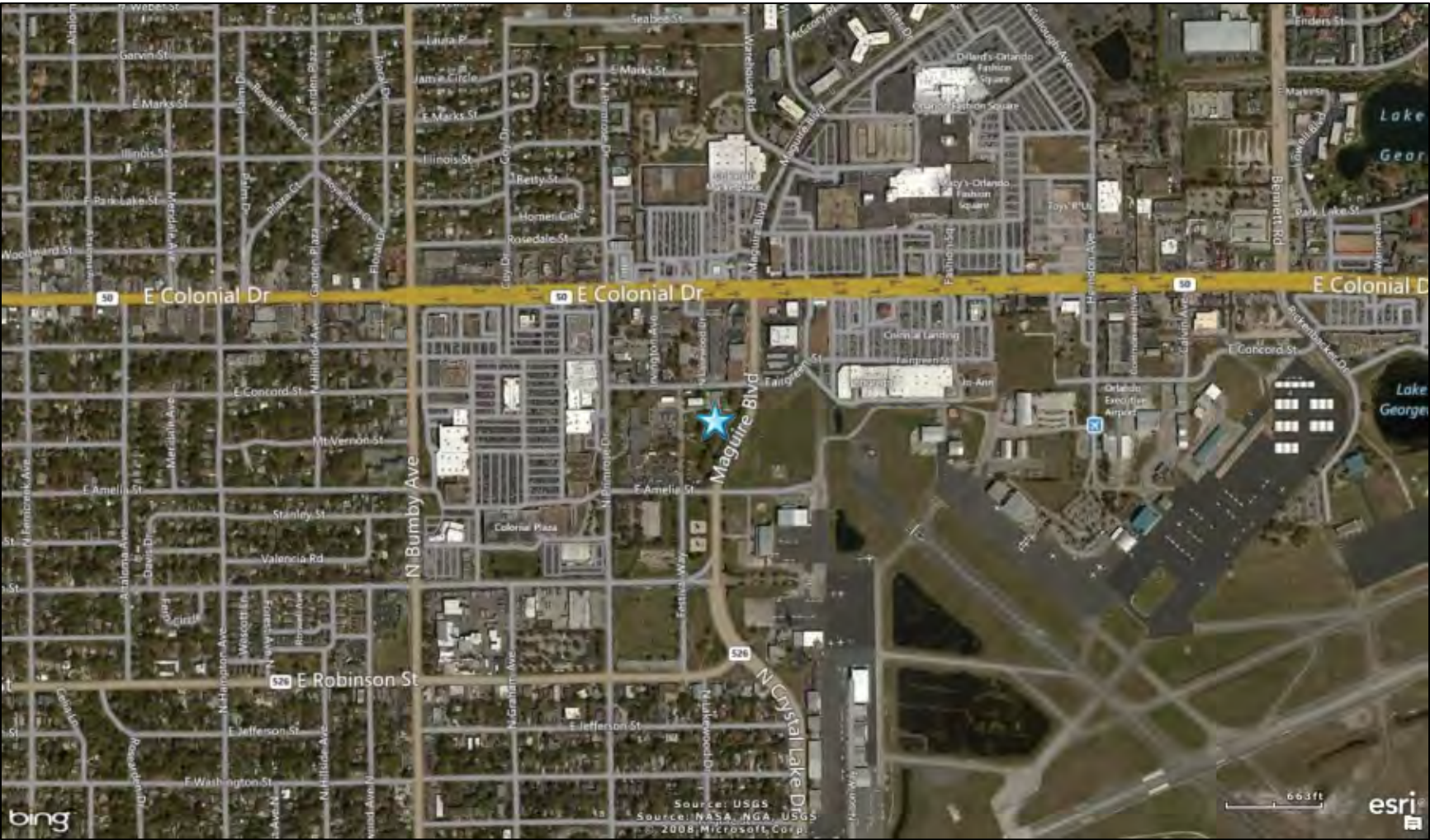


Figure 10-8. NEI Point Sources Located Within 10 Miles of ORFL and PAFL

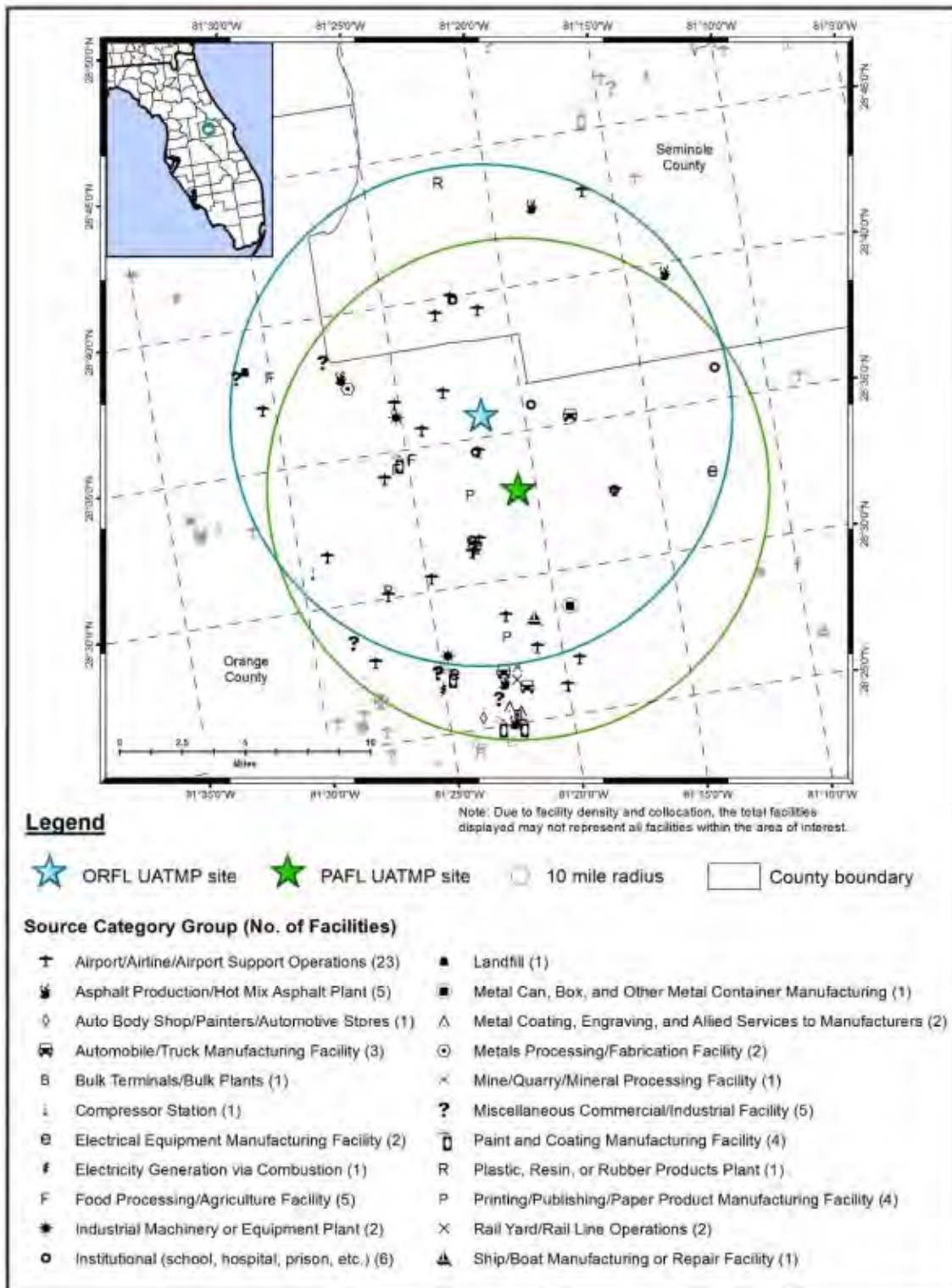


Figure 10-9. Belle Glade, Florida (WPFL) Monitoring Site

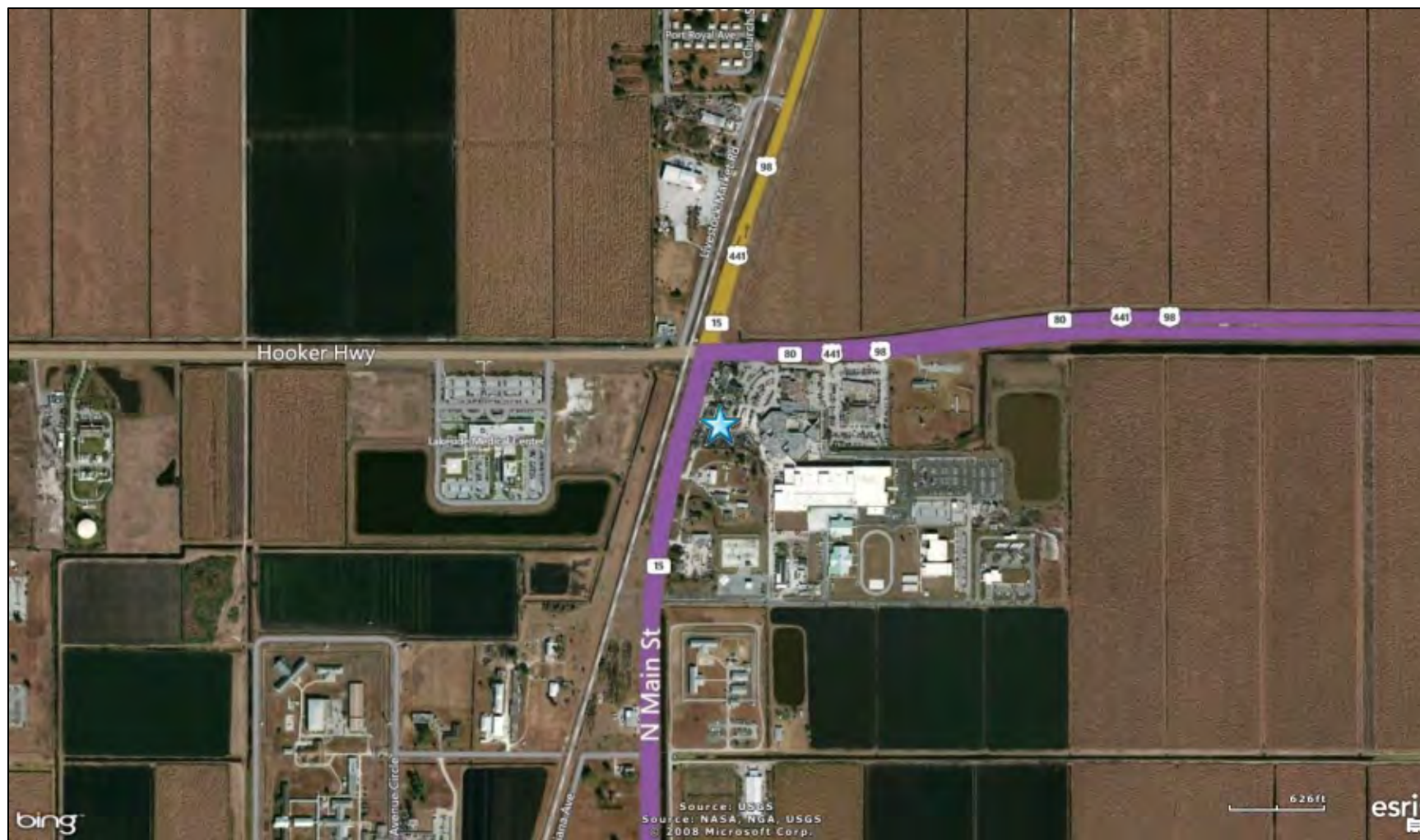


Figure 10-10. NEI Point Sources Located Within 10 Miles of WPFL

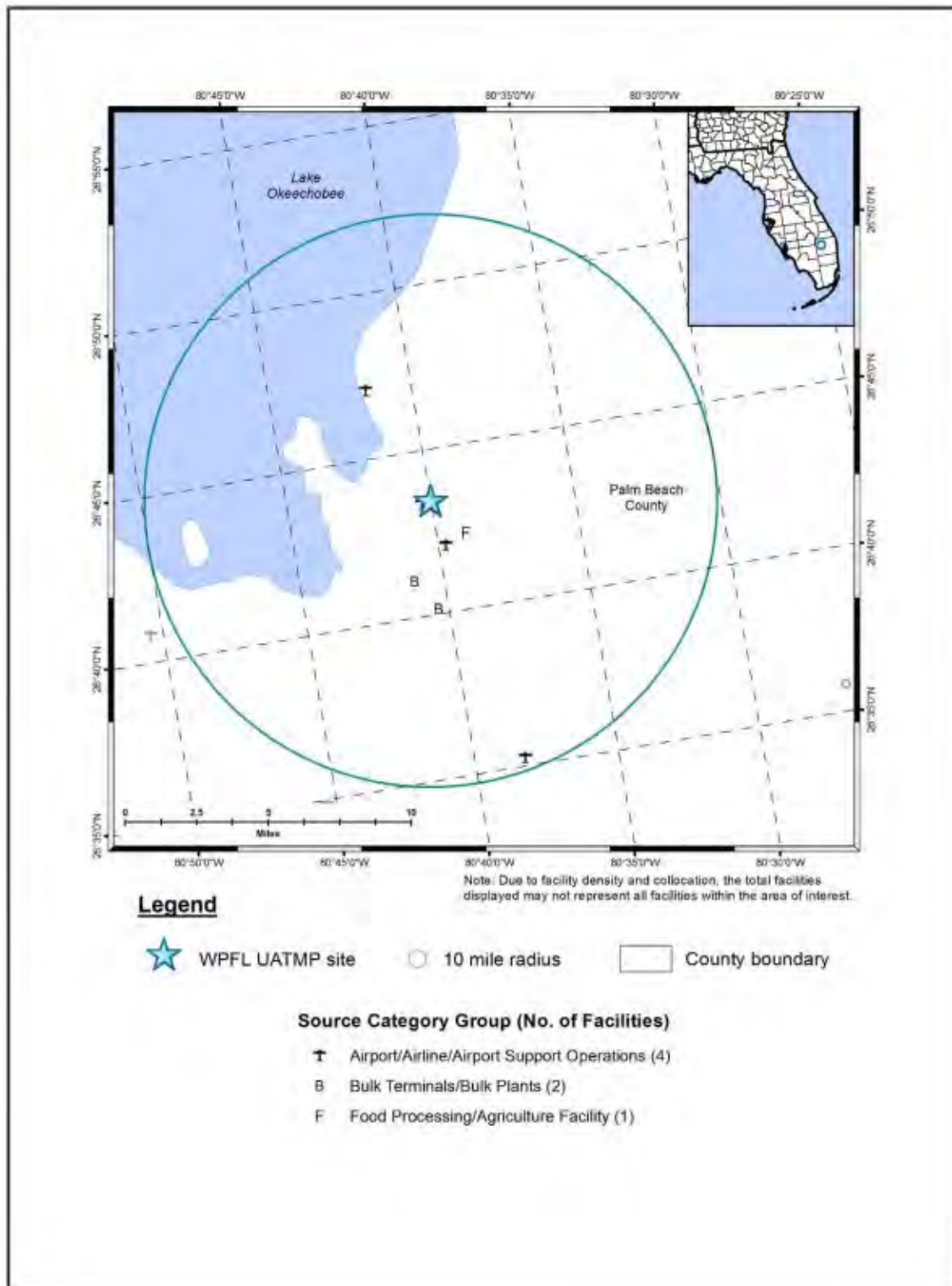


Table 10-1. Geographical Information for the Florida Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
AZFL	12-103-0018	St. Petersburg	Pinellas	Tampa-St. Petersburg-Clearwater, FL	27.785556, -82.74	Residential	Suburban	NO, NO ₂ , NO _x , VOCs, O ₃ , Meteorological parameters, PM ₁₀ , PM ₁₀ Speciation, PM _{2.5} .
<i>SKFL</i>	12-103-0026	Pinellas Park	Pinellas	Tampa-St. Petersburg-Clearwater, FL	27.850348, -82.714465	Residential	Suburban	VOCs, Meteorological parameters, PM ₁₀ Speciation, Black carbon, PM _{2.5} Speciation, IMPROVE Speciation.
<i>SYFL</i>	12-057-3002	Valrico	Hillsborough	Tampa-St. Petersburg-Clearwater, FL	27.96565, -82.2304	Residential	Rural	CO, SO ₂ , NO _y , NO, NO _x , VOCs, O ₃ , Meteorological parameters, PM ₁₀ , PM ₁₀ Speciation, PM _{2.5} , PM _{2.5} Speciation, PM Coarse, IMPROVE Speciation.
ORFL	12-095-2002	Winter Park	Orange	Orlando-Kissimmee-Sanford, FL	28.596389, -81.3625	Commercial	Urban/City Center	CO, SO ₂ , NO, NO ₂ , NO _x , VOCs, O ₃ , Meteorological parameters, PM ₁₀ , PM _{2.5} , PM _{2.5} Speciation.
PAFL	12-095-1004	Orlando	Orange	Orlando-Kissimmee-Sanford, FL	28.550833, -81.345556	Commercial	Suburban	None.
WPFL	12-099-0008	Belle Glade	Palm Beach	Miami-Ft. Lauderdale-West Palm Beach, FL	26.724444, -80.666667	Industrial	Rural	PM _{2.5} Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

AZFL is located at Azalea Park in St. Petersburg. Figure 10-1 shows that the area surrounding AZFL consists of mixed land use, including residential, commercial, and industrial properties. The industrial property separated from Azalea Park by 72nd Street North is a former electronics manufacturer and is a permanently closed facility (EPA, 2015e). Heavily traveled roadways are located less than 1 mile from the monitoring site. AZFL is located less than 1 mile east of Boca Ciega Bay, the edge of which can be seen in the bottom-left corner of Figure 10-1.

SKFL is located in Pinellas Park, north of St. Petersburg. This site is located on the property of Skyview Elementary School at the corner of 86th Avenue North and 60th Street North. Figure 10-2 shows that SKFL is located in a primarily residential area. However, a railroad intersects the Pinellas Park Ditch near a construction company on the left-hand side of Figure 10-2. Population exposure is the purpose behind monitoring at this location. This site is the Pinellas County NATTS site.

Figure 10-3 shows the location of the St. Petersburg sites in relation to each other. AZFL is located approximately 5 miles south-southwest of SKFL. Most of the emissions sources on the Tampa Bay Peninsula are located north of SKFL. A small cluster of point sources is also located southeast of SKFL. The airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; printing, publishing, and paper product manufacturing; metals processing and fabrication; and ship/boat manufacturing or repair are the source categories with the greatest number of emissions sources in the St. Petersburg area (based on the areas covered by the 10-mile radii). The emissions source closest to AZFL is a plastic, resin, or rubber products plant. While the emissions source closest to SKFL falls into the miscellaneous commercial/industrial facility source category, a plastic, resin, or rubber products plant, a metals processing/fabrication facility, and a ship/boat manufacturing or repair facility are also located within 2 miles of SKFL.

SYFL is located in Valrico, which is also part of the Tampa-St. Petersburg-Clearwater, Florida CBSA, although it is on the eastern outskirts of the area. The SYFL monitoring site is located in a rural area, although, as Figure 10-4 shows, a residential community and country club lie just to the west of the site. Located to the south of the site (and shown in the bottom-center portion of Figure 10-4) are tanks that are part of the local water treatment facility. This site

serves as a background site, although the effect of increased development in the area is likely being captured by the monitoring site. This site is the Tampa NATTS site.

Figure 10-5 shows that most of the emissions sources surrounding SYFL are greater than 5 miles away from the site. The point sources shown cover a number of sources categories. The airport source category and metals processing and fabrication are the source categories with the greatest number of emissions sources near SYFL. The closest source to SYFL is the water treatment facility pictured in Figure 10-4. However, this facility is not shown in Figure 10-5 because they had no reportable air emissions in the 2011 NEI. Besides the water treatment facility, a food processing facility is the next closest emissions source to SYFL.

ORFL is located in Winter Park, north of Orlando. Figure 10-6 shows that ORFL is located near Lake Mendosen, just behind Community Playground. The site is east of Lake Killarney and south of Winter Park Village. This site lies in a commercial area and serves as a population exposure site.

PAFL is located in northeast Orlando, on the northwestern edge of the Orlando Executive Airport property, as shown in Figure 10-7. The area is considered commercial and experiences heavy traffic. The airport is bordered by Colonial Drive to the north and the East-West Expressway (Toll Road 408) to the south (although not shown in Figure 10-7). A large shopping complex is located to the northeast of the site, just north of the airport, between Colonial Drive and Maguire Boulevard. Interstate-4 runs north-south approximately 2 miles to the west of the monitoring site.

Figure 10-8 shows that ORFL is located 3.3 miles north-northwest of PAFL. Most of the point sources are located on the western side of the 10-mile radii. Although the emissions sources surrounding ORFL and PAFL are involved in a variety of industries and processes, the airport and airport support operations source category has the greatest number of emissions sources within 10 miles of these sites. The closest emissions source to PAFL is Orlando Executive Airport, which is located under the star symbol for PAFL in Figure 10-8. The closest emissions source to ORFL is a hospital, which falls into the institutions category, and the heliport located at the hospital, which falls into the airport source category.

The WPFL monitoring site is located north of Belle Glade, a rural town west of most of the urbanized areas of Palm Beach County. The monitoring site is located on the property of the Palm Beach County Health Center and is surrounded by medical and municipal services, as well as the detention center for the sheriff's office. Lake Okeechobee is located about 4 miles northwest of the site at its nearest point. The town is surrounded by various agricultural areas to the east, south, and west, where sugar cane is the primary crop. A sugar mill is the closest major source to WPFL. Although the Everglades are located roughly 65 miles to the south of the site, various wildlife, conservation, and flood control areas are located between the site and the national park.

Figure 10-10 shows that a total of seven point sources are located within 10 miles of WPFL. More than half of the point sources are in the airport source category, including the source located under the star symbol for WPFL in Figure 10-10, which is a hospital heliport. The aforementioned sugar mill is the "F" symbol located to the southeast of WPFL in Figure 10-10.

Table 10-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Florida monitoring sites. Table 10-2 includes both county-level population and vehicle registration information. Table 10-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 10-2 presents the county-level daily VMT for Pinellas, Hillsborough, Orange and Palm Beach Counties.

Table 10-2. Population, Motor Vehicle, and Traffic Information for the Florida Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
AZFL	Pinellas	929,048	879,683	42,500	66th St N, N of 9th St	21,460,593
SKFL				47,500	Park Blvd, E of 66th St N	
SYFL	Hillsborough	1,291,578	1,157,057	10,000	MLK, east of McIntosh Rd	34,614,572
ORFL	Orange	1,225,267	1,181,540	29,500	Orlando Ave, N of Morse Blvd	34,904,854
PAFL				49,000	Colonial/MLK Blvd, b/w Primrose Rd & Bumby Ave	
WPFL	Palm Beach	1,372,171	1,159,114	6,600	Hwy 98 (Belle Glade Rd), north of Hooker Hwy	33,617,131

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect 2013 data (FL DHSMV, 2013)

³AADT reflects 2013 data (FL DOT, 2013a)

⁴County-level VMT reflects 2013 data (FL DOT, 2013b)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 10-2 include the following:

- Palm Beach County, where WPFL is located, is the most populous of the Florida counties with NMP sites, although Orange County and Hillsborough County also have more than 1 million people each and Pinellas County has just less 1 million people. These counties rank close to each other compared to other counties with NMP sites, ranking between 10th and 15th in population. Note that WPFL is located well to the west of the center of population in Palm Beach County, which is oriented along the eastern third of the county, near the coast.
- The vehicle registration counts for three of the four Florida counties are greater than 1 million, with Orange County having the most and Pinellas County having the least. The vehicle registration rankings for the Florida sites are very similar to the county population rankings compared to other counties with NMP sites, ranking between ninth and 14th.
- The traffic volume is lowest near SYFL and highest near PAFL, among the Florida sites, although the traffic volume for SKFL is similar to the traffic volume near PAFL. The traffic volume for PAFL ranks 21st among other NMP sites, with the traffic volumes for SKFL, AZFL, and ORFL in the middle of the range compared to other NMP sites. The traffic near SYFL is in the bottom third compared to other NMP sites.
- The VMTs for Orange, Hillsborough, and Palm Beach Counties are fairly similar to each other, around roughly 34 million miles and ranking eighth, ninth, and 10th compared to the VMTs for other counties with NMP sites. The VMT for Pinellas County is considerably less at roughly 21 million, but is still among the highest VMTs, ranking 16th among counties with NMP sites.

10.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Florida on sample days, as well as over the course of the year.

10.2.1 Climate Summary

The state of Florida is characterized by mild winters and warm, humid summers. Temperatures below freezing are infrequent while temperatures reaching 90°F are common from May to September. Florida receives more precipitation than any other state except Louisiana. Precipitation tends to be concentrated during the summer months, as afternoon thunderstorms occur almost daily. Semi-permanent high pressure over the Atlantic Ocean extends westward towards Florida in the winter, resulting in reduced precipitation amounts and mainly sunny skies. Land and sea breezes affect coastal locations and the proximity to the Atlantic Ocean or Gulf of Mexico can have a marked effect on local meteorological conditions. Florida's orientation and

location between the warm waters of the Gulf of Mexico, the Atlantic Ocean, and Caribbean Sea make it susceptible to tropical systems. However, Orlando's land-locked location generally makes it less vulnerable than the coastal areas (Wood, 2004; FCC, 2015).

10.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the Florida monitoring sites (NCDC, 2013), as described in Section 3.4.2. The weather station closest to the AZFL monitoring site is located at St. Petersburg/Whitted Airport (WBAN 92806); closest to SKFL is the St. Petersburg/Clearwater International Airport weather station (WBAN 12873); closest to SYFL is the Vandenberg Airport weather station (WBAN 92816); closest to both ORFL and PAFL is the Orlando Executive Airport weather station (WBAN 12841); and closest to WPFL is the Palm Beach International Airport weather station (WBAN 12844). Additional information about each of these weather stations, such as the distance between the sites and the weather stations, is provided in Table 10-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 10-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 10-3 is the 95 percent confidence interval for each parameter. As shown in Table 10-3, average meteorological conditions on sample days in 2013 at the Florida monitoring sites were representative of average weather conditions experienced throughout the entire year. The largest difference is shown for WPFL for relative humidity. Note that sampling at WPFL took place on a 1-in-12 day schedule from March 2013 through March 2014, yielding roughly 13 months of sample days. This is the only site where any 2014 data is incorporated into the 2013 NMP report.

Table 10-3. Average Meteorological Conditions near the Florida Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
St. Petersburg, Florida - AZFL									
St. Petersburg/Whitted Airport 92806 (27.76, -82.63)	7.1 miles	Sample Days (61)	81.6 ± 2.0	75.2 ± 2.0	66.5 ± 2.2	69.6 ± 1.9	76.0 ± 2.1	1017.5 ± 1.0	7.7 ± 0.6
	103° (ESE)	2013	81.5 ± 0.8	75.1 ± 0.8	65.9 ± 1.0	69.3 ± 0.9	74.5 ± 1.0	1017.3 ± 0.4	8.0 ± 0.3
Pinellas Park, Florida - SKFL									
St Petersburg-Clearwater Intl. Airport 12873 (27.91, -82.69)	4.5 miles	Sample Days (63)	81.4 ± 2.2	73.2 ± 2.1	63.9 ± 2.5	67.4 ± 2.2	74.4 ± 2.1	1018.1 ± 1.0	6.5 ± 0.5
	22° (NNE)	2013	81.7 ± 0.8	73.6 ± 0.9	64.1 ± 1.1	67.8 ± 0.9	74.0 ± 1.0	1017.8 ± 0.4	6.8 ± 0.3
Valrico, Florida - SYFL									
Vandenberg Airport 92816 (28.01, -82.35)	7.8 miles	Sample Days (61)	83.5 ± 2.0	72.4 ± 2.1	63.6 ± 2.5	67.0 ± 2.2	76.9 ± 2.1	NA	2.9 ± 0.4
	295° (WNW)	2013	83.6 ± 0.8	72.4 ± 0.9	63.3 ± 1.1	66.8 ± 0.9	75.9 ± 0.8	NA	3.1 ± 0.2
Winter Park, Florida - ORFL									
Orlando Executive Airport 12841 (28.55, -81.33)	4.0 miles	Sample Days (61)	81.9 ± 2.0	72.8 ± 1.9	62.9 ± 2.6	66.8 ± 2.1	73.6 ± 2.4	1018.6 ± 1.0	6.0 ± 0.5
	153° (SSE)	2013	82.1 ± 0.8	72.8 ± 0.8	62.7 ± 1.1	66.8 ± 0.9	73.4 ± 1.1	1018.5 ± 0.4	6.0 ± 0.2

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA= Sea level pressure was not recorded at the Vandenberg Airport.

Table 10-3. Average Meteorological Conditions near the Florida Monitoring Sites (Continued)

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Orlando, Florida - PAFL									
Orlando Executive Airport 12841 (28.55, -81.33)	0.9 miles	Sample Days (30)	82.1 ± 2.9	73.2 ± 2.7	63.3 ± 3.7	67.1 ± 3.0	73.4 ± 3.3	1018.5 ± 1.3	6.1 ± 0.7
	117° (ESE)	2013	82.1 ± 0.8	72.8 ± 0.8	62.7 ± 1.1	66.8 ± 0.9	73.4 ± 1.1	1018.5 ± 0.4	6.0 ± 0.2
Belle Glade, Florida - WPFL									
Palm Beach Intl. Airport 12844 (26.68, -80.10)	35.2 miles	Sample Days (34)	82.8 ± 1.9	76.3 ± 2.2	65.8 ± 2.6	69.6 ± 2.2	74.5 ± 3.2	1017.0 ± 0.9	7.3 ± 0.8
	94° (E)	Mar 2013 - Mar 2014	82.3 ± 0.6	76.0 ± 0.7	65.3 ± 0.8	69.2 ± 0.7	70.8 ± 0.9	1016.9 ± 0.3	8.0 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA= Sea level pressure was not recorded at the Vandenberg Airport.

The Florida sites have some of the highest daily average temperatures among the NMP sites, behind only the Arizona sites. The highest average dew point and wet bulb temperatures among NMP sites were calculated for the Florida monitoring sites. The Tampa/St. Petersburg sites and the Orlando sites also experienced some of the highest relative humidity levels among NMP sites, behind only the Mississippi sites. While AZFL ranks among the windier locations, with an average wind speed around 8 knots, SYFL ranks among the least windy locations, with an average wind speed around 3 knots.

10.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations nearest the Florida sites, as presented in Section 10.2.2, were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

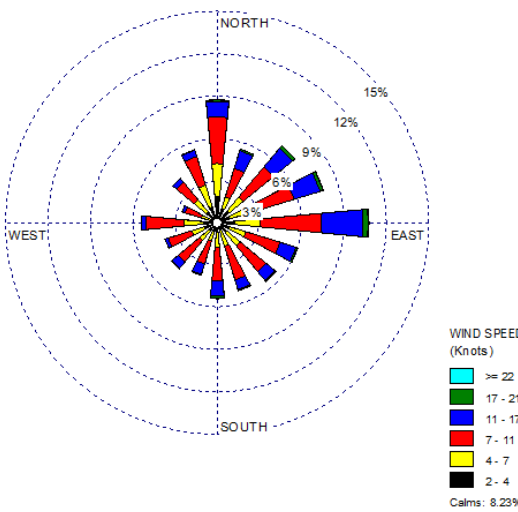
Figure 10-11 presents a map showing the distance between the weather station and AZFL, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 10-11 also presents three different wind roses for the AZFL monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 10-12 through 10-16 present the three wind roses and distance maps for SKFL, SYFL, ORFL, PAFL, and WPFL, respectively. Note that the full-year wind rose for WPFL includes data from March 2013 through March 2014.

Figure 10-11. Wind Roses for the St. Petersburg/Whitted Airport Weather Station near AZFL

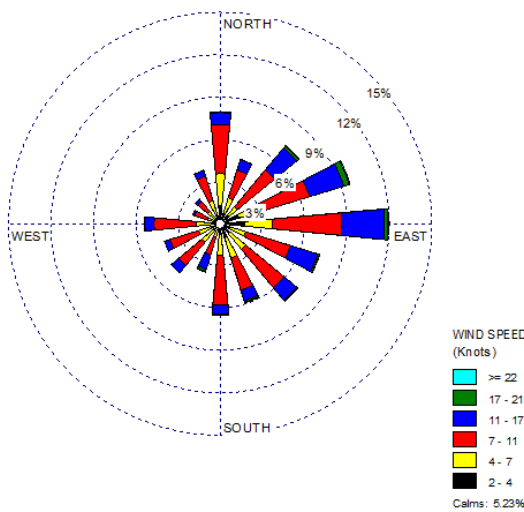
Location of AZFL and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

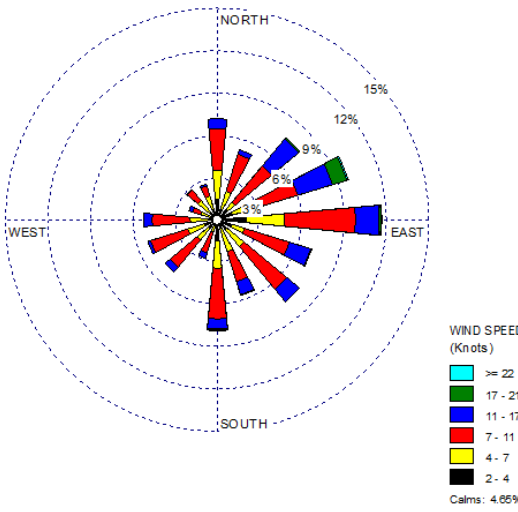
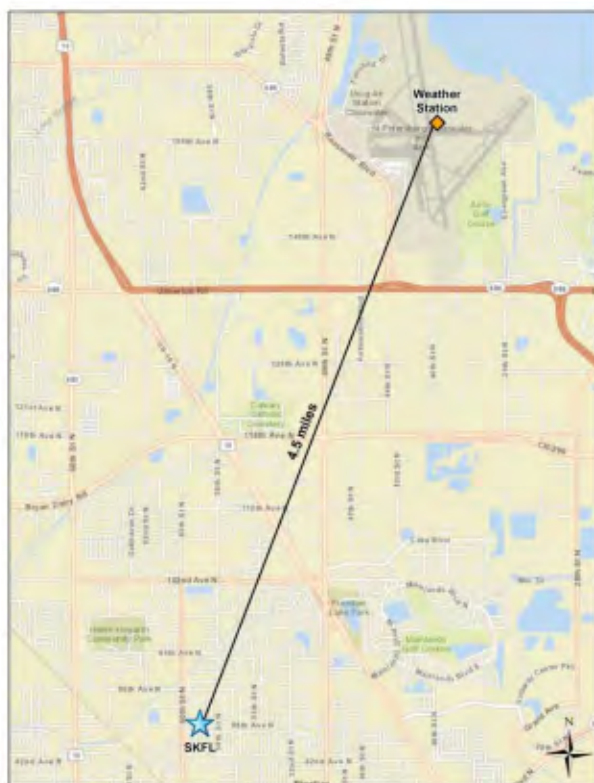
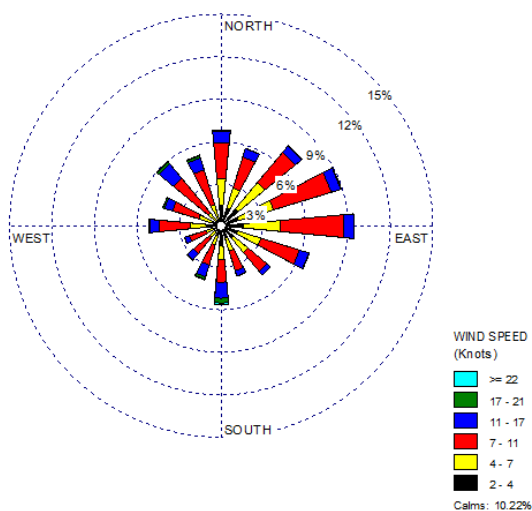


Figure 10-12. Wind Roses for the St. Petersburg/Clearwater International Airport Weather Station near SKFL

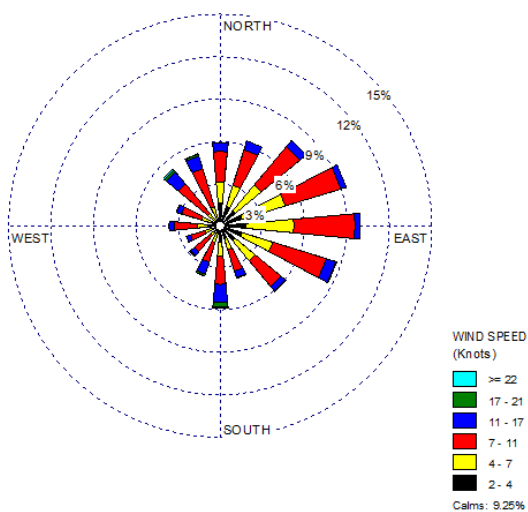
Location of SKFL and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

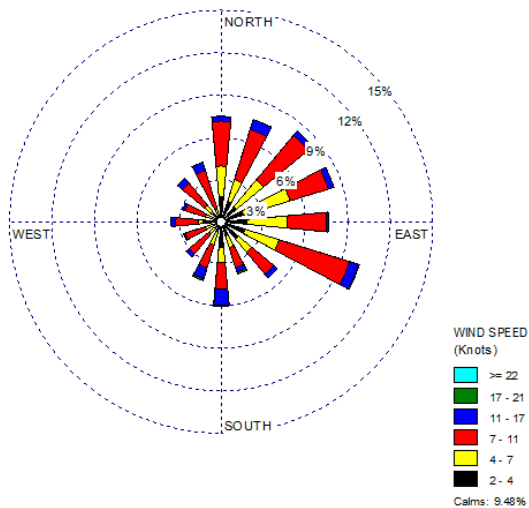
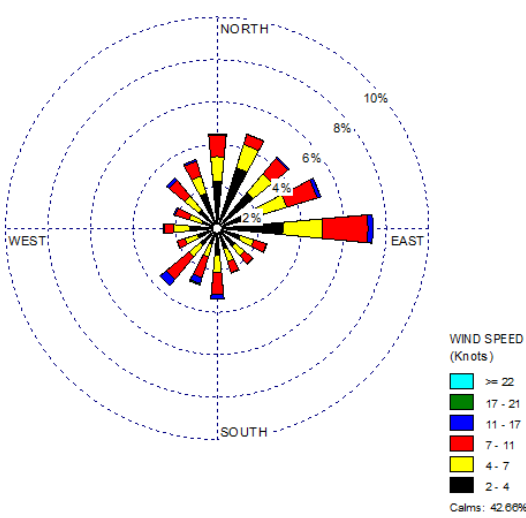


Figure 10-13. Wind Roses for the Vandenberg Airport Weather Station near SYFL

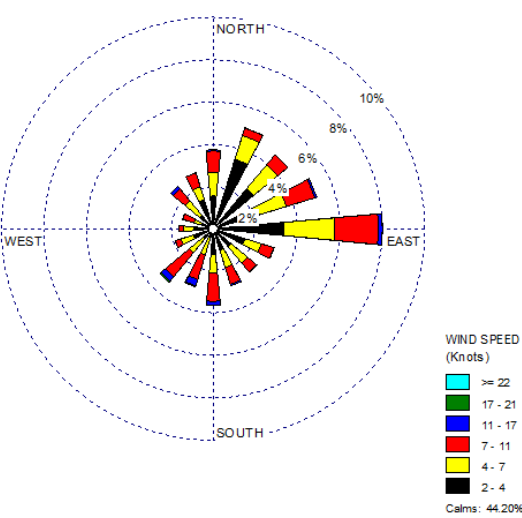
Location of SYFL and Weather Station



2005-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

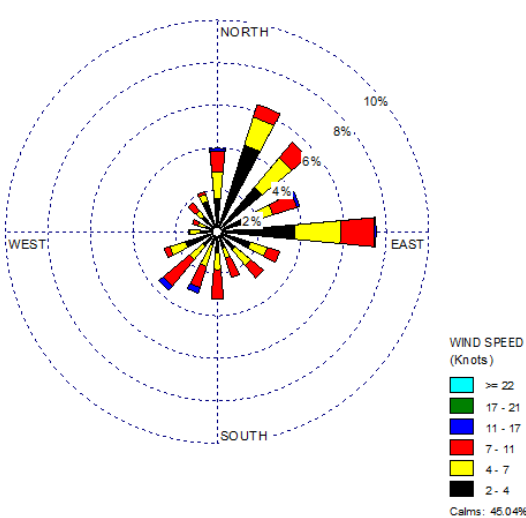
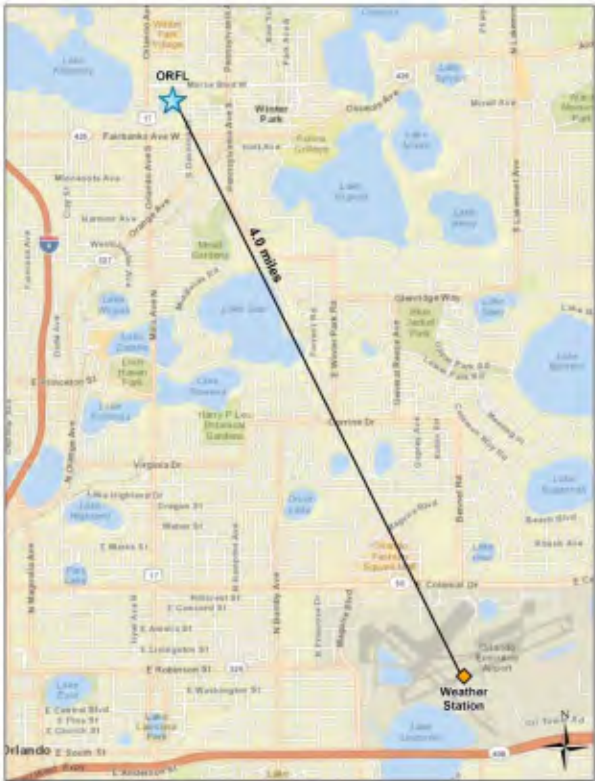
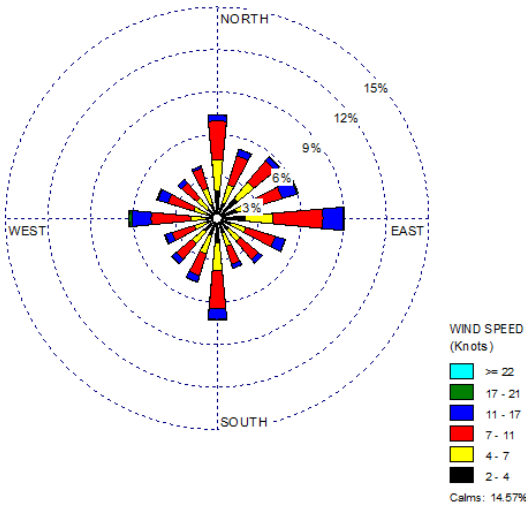


Figure 10-14. Wind Roses for the Orlando Executive Airport Weather Station near ORFL

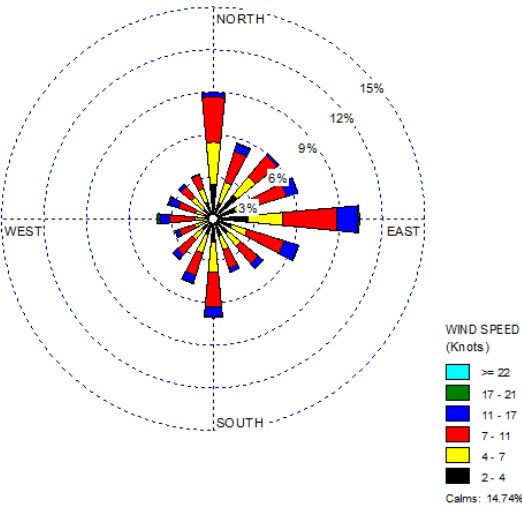
Location of ORFL and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

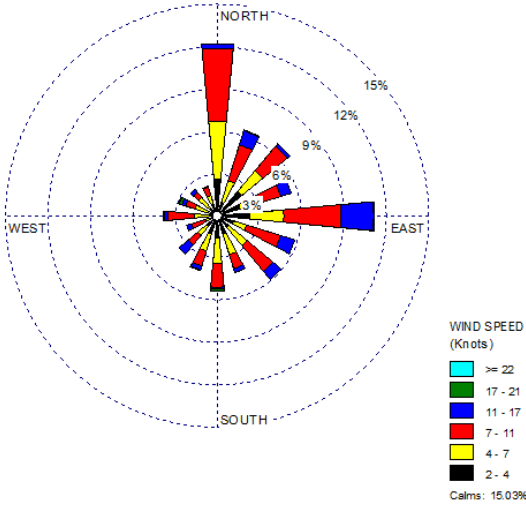
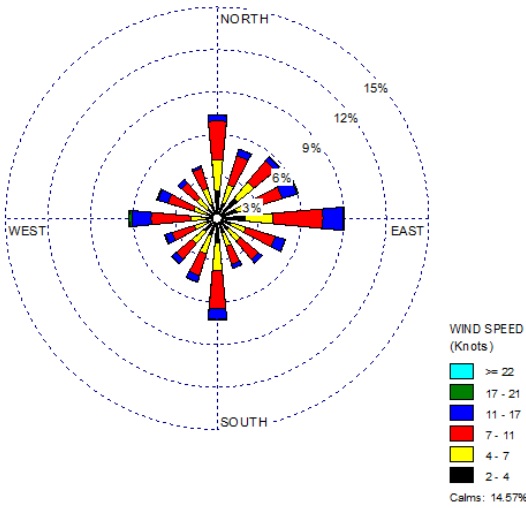


Figure 10-15. Wind Roses for the Orlando Executive Airport Weather Station near PAFL

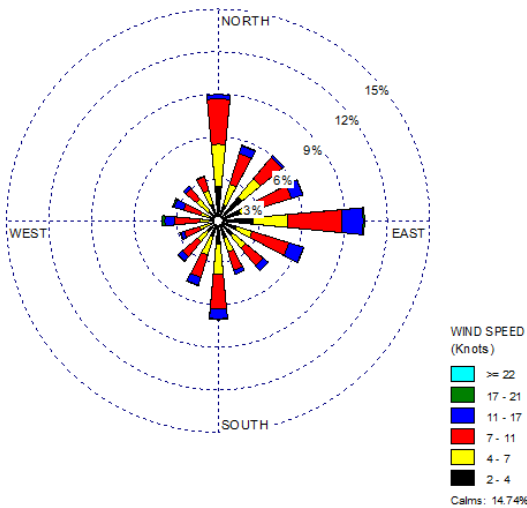
Location of PAFL and Weather Station



2002-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

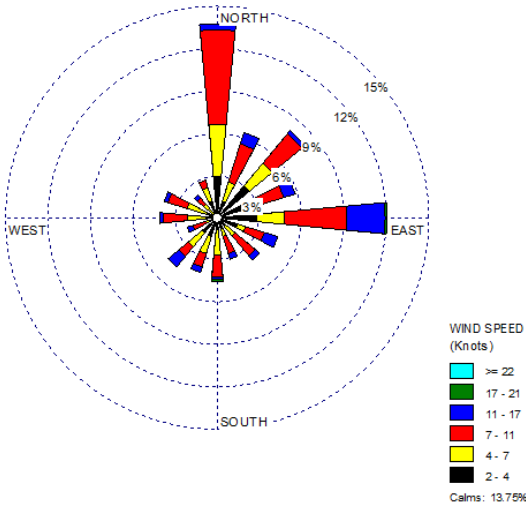
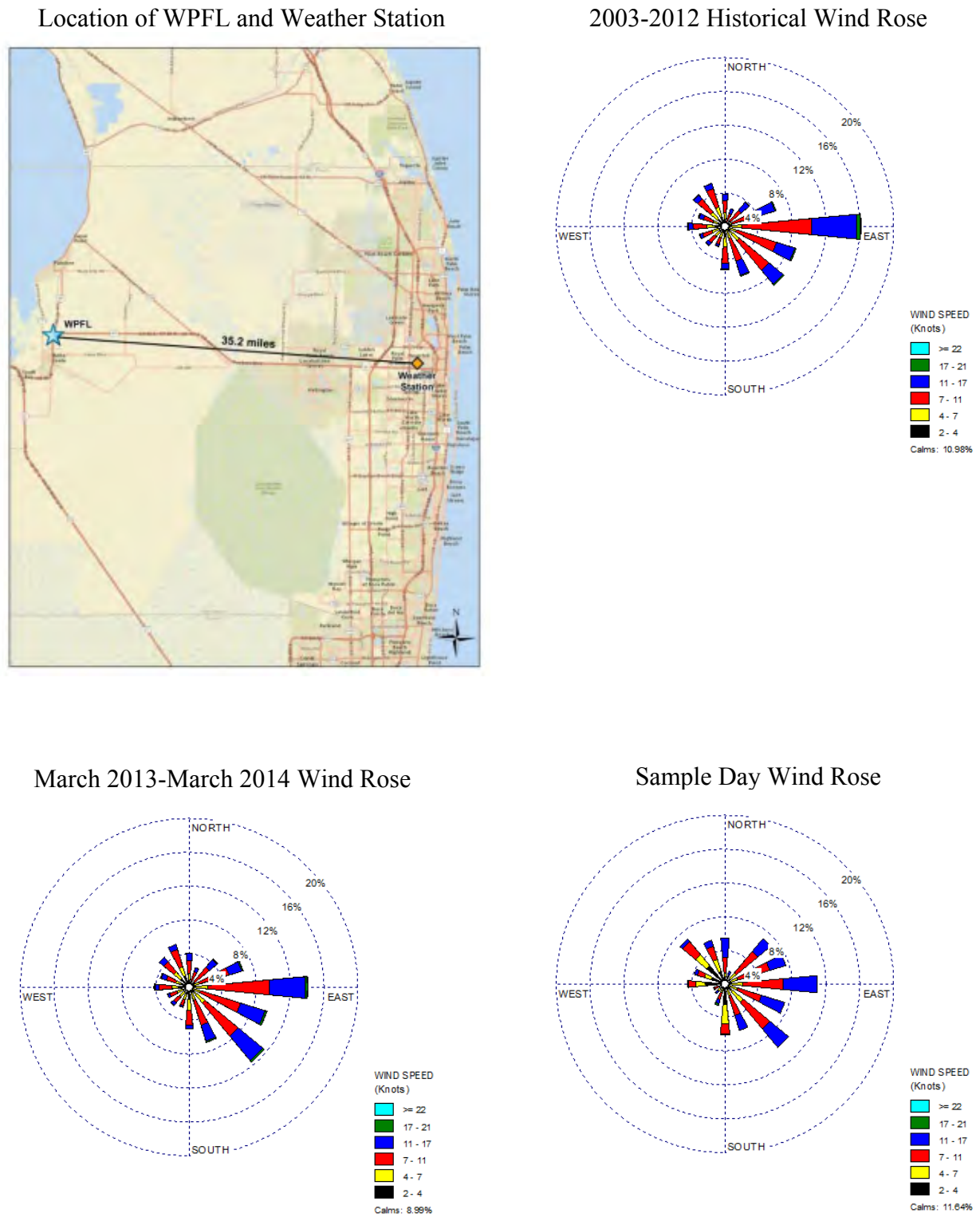


Figure 10-16. Wind Roses for the Palm Beach International Airport Weather Station near WPFL



Observations from Figure 10-11 for AZFL include the following:

- The weather station at St. Petersburg/Whitted Airport is located 7.1 miles east-southeast of AZFL. Between them is most of the city of St. Petersburg. Note that the Whitted Airport is located on the Tampa Bay coast while AZFL is on the west side of the peninsula near the Boca Ciega Bay.
- The historical wind rose shows that winds from the north, northeast quadrant, and east were the most commonly observed wind directions near AZFL, accounting for approximately 40 percent of observations. Winds from the western quadrants were observed less frequently than winds from the eastern quadrants. Calm winds (those less than or equal to 2 knots) account for roughly 8 percent of the hourly wind measurements over the last 10 years.
- The full-year wind rose shows that fewer calm winds were observed in 2013. In addition, a higher percentage of winds from the east-northeast, east, east-southeast, and southeast were observed in 2013.
- The sample day wind patterns resemble the full-year wind patterns, with east-northeasterly and easterly winds observed most often. There were even fewer calm winds (less than 5 percent) observed on sample days.

Observations from Figure 10-12 for SKFL include the following:

- The weather station at St. Petersburg/Clearwater International Airport is located 4.5 miles north-northeast of SKFL. The St. Petersburg/Clearwater Airport is located on Old Tampa Bay while SKFL is located farther inland.
- The historical wind rose shows that winds from a variety of directions were observed near SKFL, although winds from the north and northeast to east-southeast were the most commonly observed wind directions. Winds from the southwest quadrant were observed infrequently. Calm winds account for approximately 10 percent of the hourly wind measurements.
- The 2013 wind rose resembles the historical wind rose in that winds from the northeast to east-southeast account for a majority of the wind observations. Winds from the southeast account for slightly more wind observations while winds from the north account for slightly less. The percentage of calm winds for 2013 is less than 10 percent.
- Northeast to east-southeast winds account for a majority of the wind observations on sample days near SKFL, but northerly and north-northeasterly winds were observed nearly as often. Together, winds from the north to east-southeast account for nearly 50 percent of the wind observations on sample days. None of the other directions account for more than 6 percent of wind observations. The percentage of calm winds on sample days is similar to the percentage of calm winds over the course of 2013.

Observations from Figure 10-13 for SYFL include the following:

- The weather station at Vandenberg Airport is located 7.8 miles west-northwest of SYFL. Note that the closest weather station to SYFL is actually located at Plant City Municipal Airport; however, data from the second closest weather station is used for this report because the meteorological sensors at Plant City Municipal Airport were down for part of 2013.
- The historical wind rose shows that calm winds account for approximately 43 percent of the hourly wind measurements between 2005 and 2012. Winds from the east were prevalent during this time period, although winds from the north, northeast quadrant, and east were observed often, together accounting for about one-quarter of the observations. Winds from the southeast quadrant were observed the least. Note that among the sites in the Tampa-St. Petersburg area, winds were lightest near SYFL, as few wind observations greater than 11 knots were measured.
- Calm winds account for a slightly higher percentage of observations on the full-year wind rose (44 percent). East was the prevailing wind direction again for 2013, accounting for a slightly higher percentage of winds (8 percent). Northerly winds were observed less frequently in 2013 while winds from the north-northeast to east-northeast each account for roughly 5 percent of wind observations.
- While easterly winds prevailed, winds from the north-northeast and northeast account for a higher percentage of wind observations on sample days near SYFL. Conversely, winds from the east-northeast account for fewer observations on sample days. Calm winds account for 45 percent of observations on sample days.

Observations from Figures 10-14 and 10-15 for ORFL and PAFL include the following:

- The closest weather station to both ORFL and PAFL is located at the Orlando Executive Airport. The weather station is located 4 miles south-southeast of ORFL and less than 1 mile east-southeast of PAFL, as PAFL is located on the edge of the Orlando Executive Airport property. Thus, the historical and full-year wind roses presented for these sites are identical. Note that the distance between PAFL and the weather station at Orlando Executive Airport is the shortest distance from a weather station among NMP sites.
- The historical wind roses show that winds from all directions were observed near these sites, with easterly winds observed the most, followed by winds from due north and due south. Winds with an easterly component were observed more often than winds with a westerly component. Calm winds were observed for less than 15 percent of the wind observations.
- The wind patterns for 2013 resemble the wind patterns on the historical wind rose, although winds from the north, with an easterly component, or south were observed even more frequently in 2013.

- The sample day wind rose for ORFL shows that winds from the north prevailed, accounting for approximately 12 percent of wind observations, followed by easterly winds, which account for roughly 11 percent of observations. Winds from the northwest quadrant were observed even less frequently on sample days.
- The sample day wind rose for PAFL shares the northerly and easterly prominence of ORFL's sample day wind rose but with a higher percentage wind observations from the northeast quadrant and slightly fewer calm winds. Note that although the sample days are fairly standardized, samples are collected at PAFL on a 1-in-12 day sampling schedule, leading to roughly half the sample days included in the sample day wind rose as ORFL.

Observations from Figure 10-16 for WPFL include the following:

- The weather station at Palm Beach International Airport is located more than 35 miles east of WPFL. The weather station is located near the Atlantic coast while WPFL is located well inland, just southeast of Lake Okeechobee. Note that the distance between WPFL and the weather station at Palm Beach International Airport is the longest distance among NMP sites.
- The historical wind rose shows that east winds are also prevalent near WPFL, accounting for 16 percent of observations. Winds from the southeast quadrant were also observed frequently near WPFL. Winds from the southwest quadrant were observed the least between 2003 and 2012. Calm winds account for nearly 11 percent of the hourly wind measurements.
- The wind patterns on the wind rose representing observations between March 2013 and March 2014 resemble those on the historical wind rose.
- Although winds from the east and southeast account for the greatest number of wind observations on sample days, the percentage is reduced compared to the full-year wind rose. Winds from the northeast, south, northwest, and north were observed more frequently on sample days near WPFL compared to the full-year wind rose, as were calm winds.

10.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Florida monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 10-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute

to the top 95 percent of the site's total failed screens and are shaded in gray in Table 10-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Carbonyl compounds were sampled for at AZFL and ORFL. Hexavalent chromium and PAHs were sampled for in addition to carbonyl compounds at SKFL and SYFL. Only PM₁₀ metals were sampled for at PAFL and only PAHs were sampled for at WPFL. Note that hexavalent chromium sampling was discontinued at SKFL and SYFL at the end of June 2013. In addition, PAH sampling was also discontinued at SYFL at the end of June 2013.

Table 10-4. Risk-Based Screening Results for the Florida Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
St. Petersburg, Florida - AZFL						
Formaldehyde	0.077	59	59	100.00	50.43	50.43
Acetaldehyde	0.45	58	59	98.31	49.57	100.00
Total		117	118	99.15		
Pinellas Park, Florida - SKFL						
Acetaldehyde	0.45	60	60	100.00	35.09	35.09
Formaldehyde	0.077	60	60	100.00	35.09	70.18
Naphthalene	0.029	50	59	84.75	29.24	99.42
Hexavalent Chromium	0.000083	1	8	12.50	0.58	100.00
Total		171	187	91.44		
Valrico, Florida - SYFL						
Acetaldehyde	0.45	61	61	100.00	45.52	45.52
Formaldehyde	0.077	61	61	100.00	45.52	91.04
Naphthalene	0.029	12	29	41.38	8.96	100.00
Total		134	151	88.74		
Winter Park, Florida - ORFL						
Acetaldehyde	0.45	61	61	100.00	50.00	50.00
Formaldehyde	0.077	61	61	100.00	50.00	100.00
Total		122	122	100.00		
Orlando, Florida - PAFL						
Arsenic (PM ₁₀)	0.00023	30	30	100.00	100.00	100.00
Total		30	30	100.00		
Belle Glade, Florida - WPFL						
Naphthalene	0.029	5	30	16.67	45.45	45.45
Acenaphthene	0.011	2	30	6.67	18.18	63.64
Fluoranthene	0.011	2	30	6.67	18.18	81.82
Fluorene	0.011	2	27	7.41	18.18	100.00
Total		11	117	9.40		

Observations from Table 10-4 include the following:

- For AZFL and ORFL, the two sites sampling only carbonyl compounds, acetaldehyde and formaldehyde were the only two pollutants to fail screens. For both sites, formaldehyde failed 100 percent of screens. For ORFL, acetaldehyde also failed 100 percent of screens. For AZFL, acetaldehyde failed one less screen than formaldehyde. Among the carbonyl compounds, only acetaldehyde, formaldehyde, and propionaldehyde have risk screening values. Propionaldehyde did not fail any screens for these two sites.
- Four pollutants failed at least one screen for SKFL; three pollutants (acetaldehyde, formaldehyde, and naphthalene) contributed to 95 percent of failed screens for SKFL and therefore were identified as pollutants of interest for this site. Hexavalent chromium was the only other pollutant to fail screens for SKFL; this pollutant was detected in eight samples collected at SKFL and failed only one screen. Acetaldehyde and formaldehyde both failed 100 percent of screens for SKFL, contributing equally to the total number of failed screens for SKFL.
- Three pollutants failed at least one screen for SYFL (acetaldehyde, formaldehyde, and naphthalene) and each of these was identified as a pollutant of interest for this site. Similar to SKFL, acetaldehyde and formaldehyde both failed 100 percent of screens for SYFL, contributing equally to the total number of failed screens.
- Arsenic is the only PM₁₀ metal to fail screens for PAFL. This pollutant was detected in every metals sample collected at PAFL and failed 100 percent of screens.
- Four PAHs failed screens for WPFL. Less than 10 percent of concentrations of these four pollutants failed screens. Naphthalene failed the highest number of screens (five) compared to the other three pollutants, all of which failed only two screens (which were all for the same two sample days). Compared to the other Florida monitoring sites sampling PAHs, this site failed relatively few screens (11 total), although the number of PAHs failing screens was greater for WPFL (four) than the other Florida sites.

10.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Florida monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at the Florida monitoring sites are provided in Appendices L, M, N, and O.

10.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Florida site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4.

Quarterly and annual average concentrations for AZFL, SKFL, SYFL, ORFL, and PAFL are presented in Table 10-5a, where applicable. Note that concentrations of the PAHs and metals are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration. Quarterly and annual average concentrations for WPFL are presented in Table 10-5b due to the differences in the sampling period for this site. Quarterly average concentrations are presented beginning with the second quarter of 2013 and continuing through the first quarter of 2014 to match the period of sampling. Note that the results presented in Table 10-5b are in ng/m^3 .

**Table 10-5a. Quarterly and Annual Average Concentrations of the Pollutants of Interest
for the Florida Monitoring Sites**

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
St. Petersburg, Florida - AZFL						
Acetaldehyde	59/59	2.27 ± 0.47	1.51 ± 0.29	1.00 ± 0.14	1.64 ± 0.32	1.63 ± 0.19
Formaldehyde	59/59	1.31 ± 0.17	1.30 ± 0.14	2.31 ± 0.27	2.19 ± 0.31	1.77 ± 0.16
Pinellas Park, Florida - SKFL						
Acetaldehyde	60/60	1.30 ± 0.23	0.96 ± 0.21	1.78 ± 0.25	1.50 ± 0.30	1.39 ± 0.14
Formaldehyde	60/60	2.21 ± 0.36	2.27 ± 0.41	0.49 ± 0.12	1.19 ± 0.17	1.54 ± 0.24
Naphthalene ^a	59/59	95.15 ± 43.83	52.76 ± 14.67	66.59 ± 20.70	61.45 ± 22.49	69.26 ± 13.80
Valrico, Florida - SYFL						
Acetaldehyde	61/61	1.75 ± 0.52	1.32 ± 0.26	1.08 ± 0.17	1.05 ± 0.18	1.30 ± 0.16
Formaldehyde	61/61	1.54 ± 0.19	2.08 ± 0.32	2.01 ± 0.31	1.67 ± 0.27	1.82 ± 0.14
Naphthalene ^a	29/29	31.84 ± 8.16	24.76 ± 5.55	NA	NA	NA
Winter Park, Florida - ORFL						
Acetaldehyde	61/61	2.66 ± 0.86	1.31 ± 0.36	1.13 ± 0.20	1.12 ± 0.16	1.55 ± 0.28
Formaldehyde	61/61	0.83 ± 0.33	2.35 ± 1.04	2.29 ± 0.34	1.87 ± 0.28	1.84 ± 0.31
Orlando, Florida - PAFL						
Arsenic (PM ₁₀) ^a	30/30	0.98 ± 0.84	0.58 ± 0.20	0.78 ± 0.52	0.58 ± 0.22	0.72 ± 0.22

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m³ for ease of viewing.

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Table 10-5b. Quarterly and Annual Average Concentrations of the Pollutants of Interest for WPFL

Pollutant	# of Measured Detections vs. # of Samples	2nd Quarter 2013 Average (ng/m ³)	3rd Quarter 2013 Average (ng/m ³)	4th Quarter 2013 Average (ng/m ³)	1st Quarter 2014 Average (ng/m ³)	Period Average (ng/m ³)
Belle Glade, Florida - WPFL						
Acenaphthene	30/30	7.39 ± 10.07	4.82 ± 4.90	2.29 ± 1.51	3.71 ± 1.96	4.62 ± 2.72
Fluoranthene	30/30	10.44 ± 13.15	6.34 ± 6.80	2.26 ± 2.28	2.82 ± 1.09	5.62 ± 3.64
Fluorene	27/30	6.01 ± 7.70	3.64 ± 3.91	2.20 ± 1.18	2.34 ± 1.43	3.66 ± 2.10
Naphthalene	30/30	13.65 ± 6.56	10.44 ± 5.28	103.00 ± 180.15	19.86 ± 6.17	35.74 ± 33.34

Observations from Table 10-5a include the following:

- The annual average concentration of formaldehyde is similar to the annual average concentration of acetaldehyde for AZFL.
- For acetaldehyde, the three acetaldehyde concentrations greater than 3 µg/m³ were measured during the first quarter and all but one of the 14 acetaldehyde concentrations greater than 2 µg/m³ were measured during the first and fourth quarters of 2013. This is reflected in the quarterly average concentrations for AZFL shown in Table 10-5a. Concentrations of formaldehyde do not follow this trend. The third and fourth quarter average concentrations of formaldehyde are significantly higher than the first and second quarter averages. The 18 highest concentrations of formaldehyde measured at AZFL were measured between July and December, with the two highest measurements collected in October (those greater than 3.0 µg/m³).
- The annual average concentration of formaldehyde is similar to the annual average concentration of acetaldehyde for SKFL.
- The quarterly average concentrations of formaldehyde for SKFL show that the concentrations measured during the first half of the year were considerably higher than those measured during the second half of the year. Concentrations measured between January and June range from 1.19 µg/m³ to 4.06 µg/m³, with a median concentration of 2.14 µg/m³; concentrations measured between July and December range from 0.297 µg/m³ to 1.74 µg/m³, with a median concentration of 0.84 µg/m³. The instrumentation at SKFL was changed at the beginning of July 2013, which may have something to do with the change in measurements. For the first half of the year, only two acetaldehyde concentrations greater than 2 µg/m³ were measured; nine were measured during the second half of the year.
- Concentrations of naphthalene measured at SKFL range from 17.1 ng/m³ to 357 ng/m³, with a median concentration of 50.6 ng/m³. The maximum concentration, measured on January 16, 2013, was nearly 100 ng/m³ greater than the next highest

concentration, which was also measured during the first quarter of 2013. Half of the 12 naphthalene concentrations greater than 100 ng/m³ were measured during the first quarter of 2013 (with no more than three measured in the other quarters of the year). This explains both the higher first quarter average as well as the variability associated with that average concentration of naphthalene for SKFL.

- Concentrations of formaldehyde were higher than concentrations of acetaldehyde measured at SYFL, based on the annual average concentrations.
- The maximum acetaldehyde concentration measured at SYFL (4.87 µg/m³) was measured on March 29, 2013 and is the only measurement greater than 3 µg/m³. Nine of the 10 highest acetaldehyde concentrations were measured at SYFL between January and May, explaining the differences shown in the quarterly averages.
- The nine highest formaldehyde concentrations were measured between April and October while all but one of the 20 lowest formaldehyde concentrations were measured between January and April or September and December. Although formaldehyde concentrations appear higher during the warmer months of the year, confidence intervals indicate that the differences are not statistically significant.
- Concentrations of formaldehyde were just slightly higher than concentrations of acetaldehyde measured at ORFL, based on the annual average concentrations.
- Concentrations of acetaldehyde at ORFL were highest during the first quarter of 2013 and appear to decrease throughout the year, based on the quarterly average concentrations. A review of the data shows that the three highest concentrations were measured in March and that nine of the 10 concentrations were measured between February and April. Conversely, most of the concentrations less than 1 µg/m³ were measured after the first quarter (two during the first quarter, six during the second quarter, and seven each during the third and fourth quarters).
- Thirteen concentrations of formaldehyde less than 1 µg/m³ were measured at ORFL, all of which were measured between January and April. This explains why the first quarter average concentration of formaldehyde is significantly less than the other quarterly averages. The maximum concentration of formaldehyde was measured at ORFL on June 9, 2013 (8.92 µg/m³) and is more twice the next highest concentration (3.66 µg/m³). With some of the lowest and highest concentrations measured during the second quarter of 2013, it makes sense that the confidence interval for the second quarter is nearly three times greater than the other confidence intervals, reflecting the variability in the measurements.
- Concentrations of naphthalene measured at SYFL range from 9.52 ng/m³ to 57.1 ng/m³, with a median concentration of 23.3 ng/m³. PAH sampling was discontinued at SYFL at the end of June 2013; thus, only first and second quarter average concentrations could be calculated.
- PAFL is the only Florida monitoring site that did not sample carbonyl compounds or PAHs. PM₁₀ metals were sampled for at PAFL and arsenic is the only pollutant

identified as a pollutant of interest for this site. Concentrations of arsenic measured at PAFL range from 0.264 ng/m³ to 3.20 ng/m³, with a median concentration of 0.53 ng/m³.

- The confidence interval for the first quarter average concentration of arsenic is just less than the average itself, indicating the potential for outliers. The maximum arsenic concentration was measured at PAFL on February 3, 2013 (3.20 ng/m³). The next highest measurement collected during this quarter was significantly less (1.03 ng/m³) and all other concentrations measured at this site are less than 2 ng/m³.

Observations from Table 10-5b for WPFL include the following:

- The period average concentrations for the pollutants of interest for WPFL show that the period average for naphthalene is an order of magnitude greater than the period averages of the other PAHs. The period averages also indicate that there is considerable variability in the measurements of these pollutants.
- Concentrations of naphthalene measured at WPFL range from 4.32 to 506 ng/m³, spanning two orders of magnitude. However, the median concentration is only 16.75 ng/m³, less than half the period average concentration. A review of the data shows that the two highest naphthalene concentrations, 506 ng/m³ measured on October 25, 2013 and 113 ng/m³ measured on March 11, 2013, are considerably higher than most of the measurements, the remainder of which are less than 33 ng/m³. WPFL's maximum naphthalene concentration is the fourth highest naphthalene measurement across the program; WPFL is one of only three NMP sites with a naphthalene measurement greater than 400 ng/m³. This explains the significant increase in the quarterly average shown for the fourth quarter of 2013 as well as the variability associated with it.
- For each of the three remaining pollutants of interest, the second quarter 2013 average concentration is considerably higher than the other quarterly average concentrations; further, the confidence intervals shown are all greater than each individual average, indicating possible outliers. The same is true for the third quarter average concentrations, but to a lesser extent. A review of the data shows that the maximum concentration of each of these pollutants was measured on June 15, 2013. In each case, the maximum concentration is more than twice the next highest concentration, which were also measured on the same day, August 2, 2013. The concentrations measured on August 2nd were also more than twice the third highest concentration. For example, the maximum concentration of fluorene measured at WPFL is 30.6 ng/m³ (June 15, 2013), followed by 13.7 ng/m³ (August 2, 2013), and 5.55 ng/m³ (May 10, 2013). All other fluorene concentrations range from 0.507 ng/m³ to 5.39 ng/m³.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Florida sites from those tables include the following:

- None of the Florida monitoring sites appear in Table 4-10 for carbonyl compounds.
- None of the Florida monitoring sites appear in Table 4-11 for naphthalene. WPFL has the seventh highest annual average concentration of acenaphthene among NMP sites sampling this pollutant. Note that WPFL is the only non-NATTS site that appears in Table 4-11.
- The annual average concentration of arsenic for PAFL ranks sixth highest among NMP sites sampling PM₁₀ metals.

10.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 10-4 for each of the Florida monitoring sites. Figures 10-17 through 10-23 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 10-17. Program vs. Site-Specific Average Acenaphthene Concentration

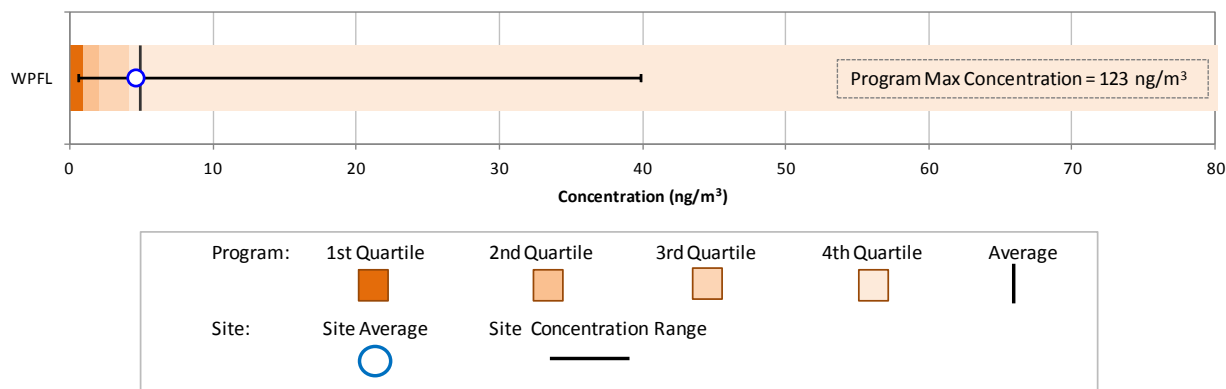


Figure 10-18. Program vs. Site-Specific Average Acetaldehyde Concentrations

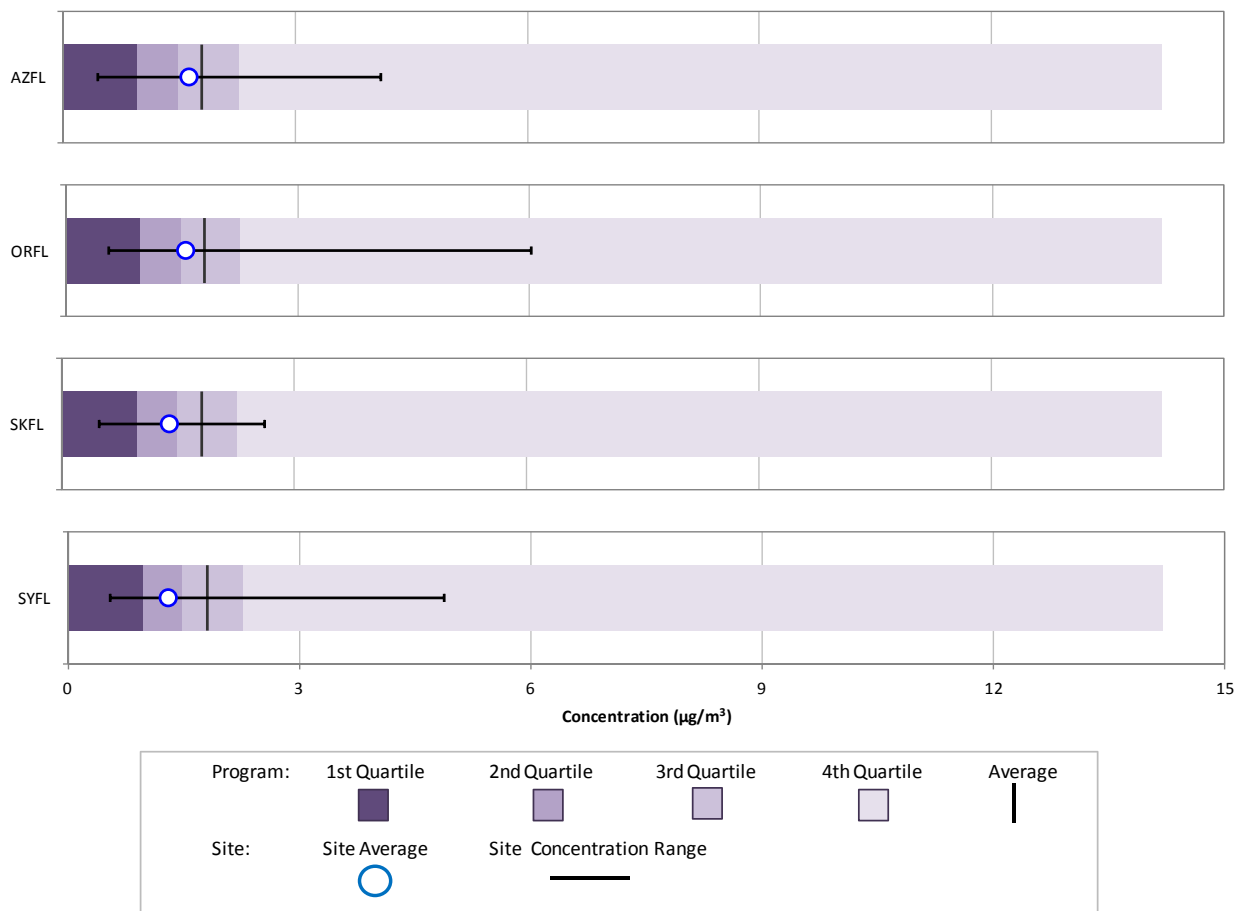


Figure 10-19. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

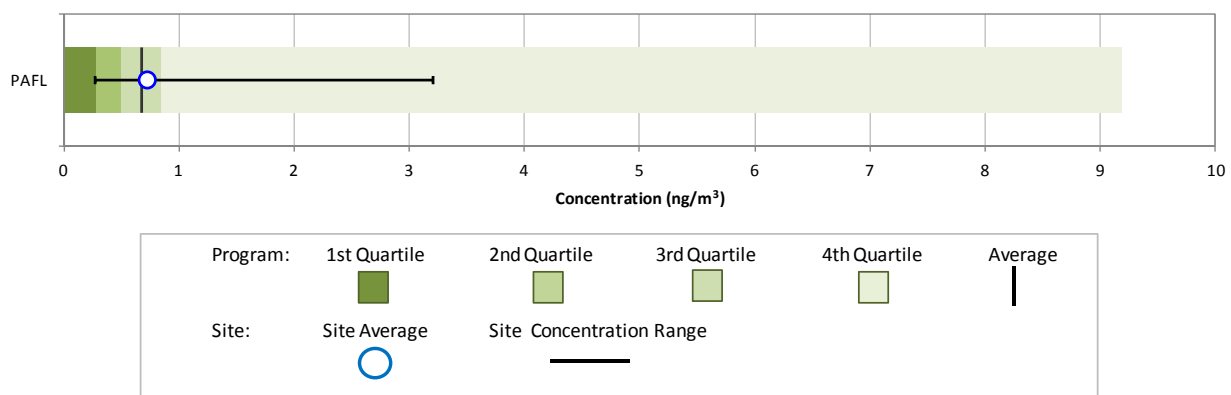


Figure 10-20. Program vs. Site-Specific Average Fluoranthene Concentration

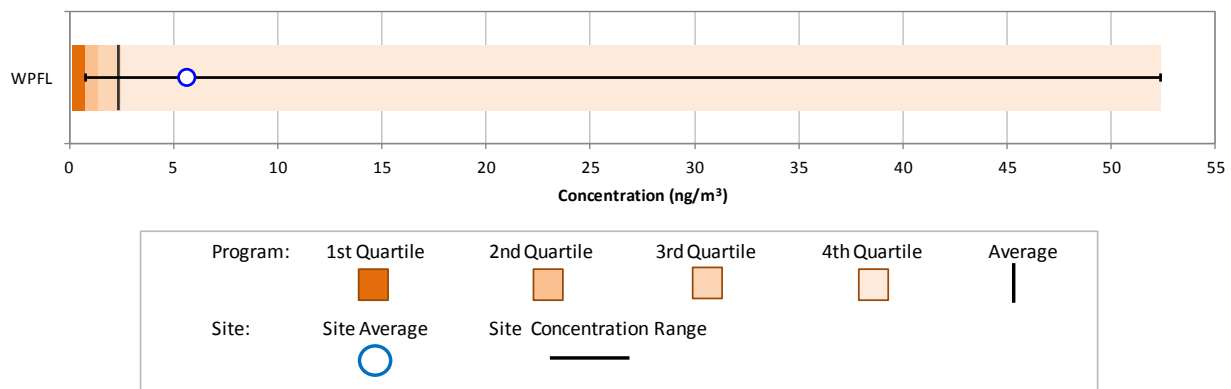


Figure 10-21. Program vs. Site-Specific Average Fluorene Concentration

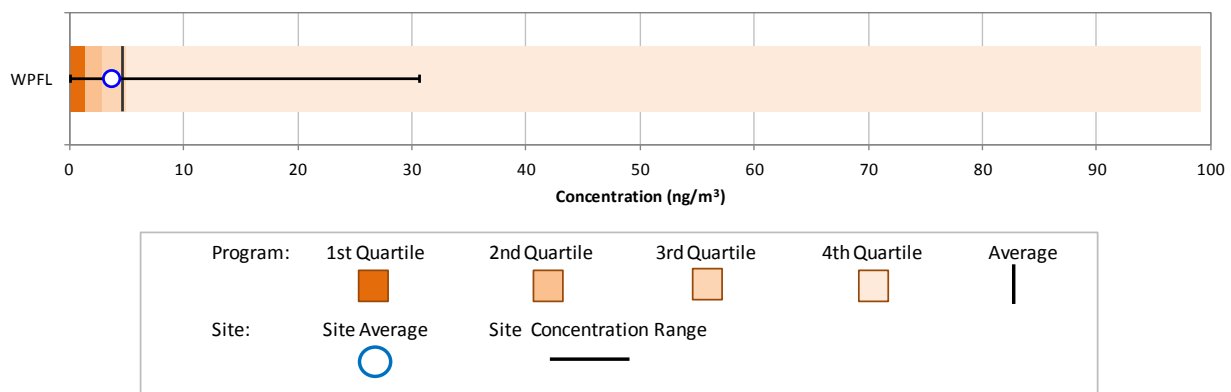


Figure 10-22. Program vs. Site-Specific Average Formaldehyde Concentrations

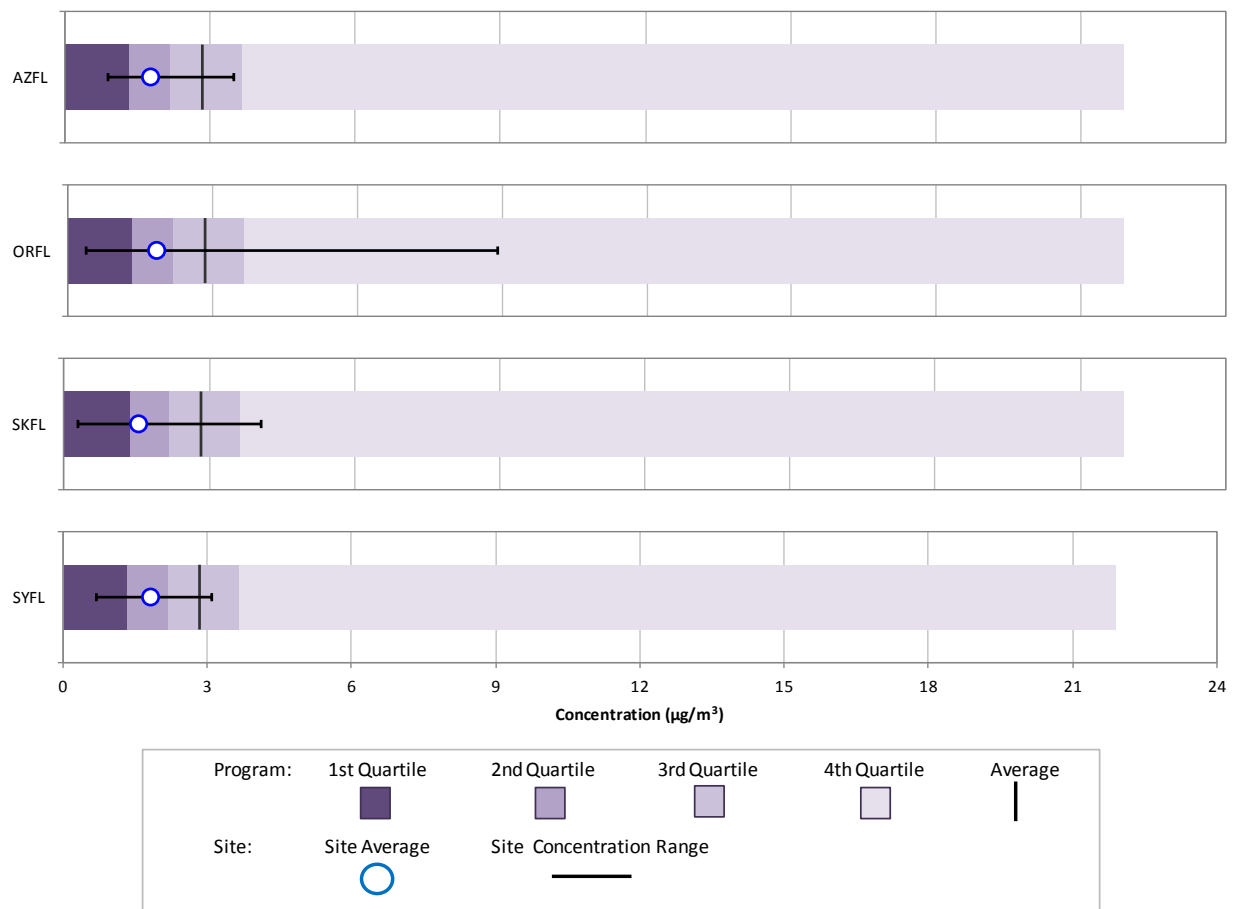
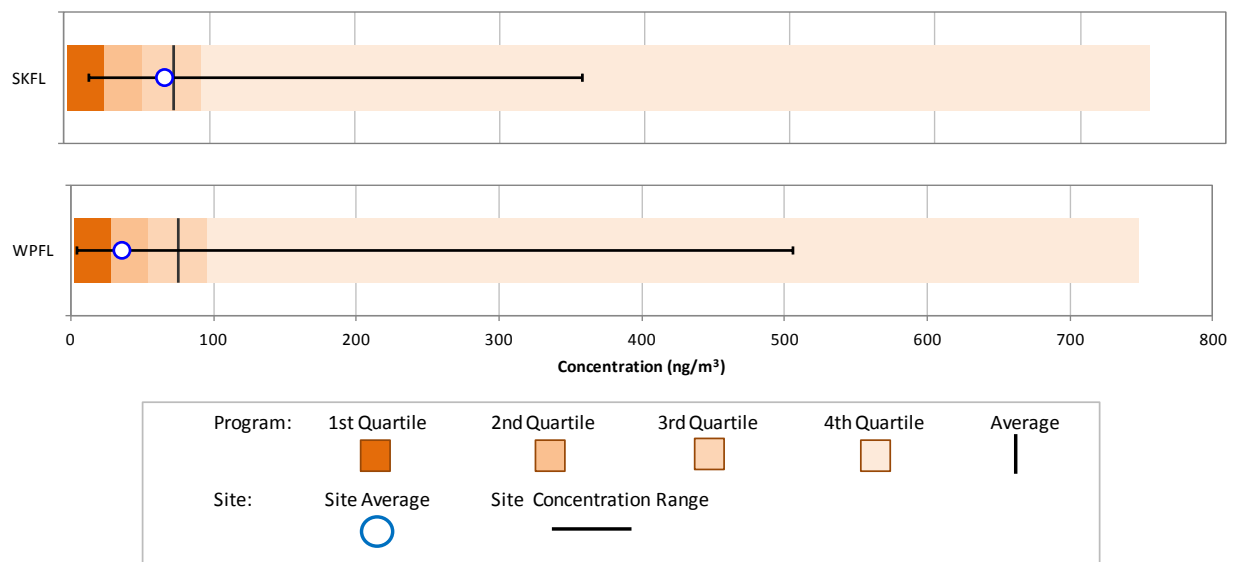


Figure 10-23. Program vs. Site-Specific Average Naphthalene Concentrations



Observations from Figures 10-17 through 10-23 include the following:

- Figure 10-17 presents the box plot for acenaphthene for WPFL, the only Florida site for which acenaphthene is a pollutant of interest. Note that the program-level maximum concentration (123 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 80 ng/m^3 . Figure 10-17 shows that concentrations of acenaphthene measured at WPFL range from 0.665 ng/m^3 to 39.9 ng/m^3 . The maximum concentration measured at PAFL is considerably less than the maximum concentration measured among NMP sites sampling PAHs. The annual average concentration for WPFL is just less than the program-level average and more than twice the program-level median concentration. Compared to other NMP sites sampling PAHs, this site's annual average concentration ranks seventh (out of 22), as discussed in the previous section.
- Figure 10-18 presents the box plots for acetaldehyde for AZFL, ORFL, SKFL, and SYFL. The box plots show that the range of acetaldehyde concentrations measured is smallest for SKFL and largest for ORFL. All of the annual average concentrations calculated for the Florida sites for which acetaldehyde is a pollutant of interest are less than the program-level average concentration. The annual averages for SKFL and SYFL are also less than the program-level median concentration.
- Figure 10-19 presents the box plot for arsenic for PAFL. The maximum arsenic concentration measured at PAFL is roughly one-third the maximum arsenic (PM_{10}) concentration measured across the program. The minimum concentration of arsenic measured at PAFL is similar to the program-level first quartile and is the highest minimum arsenic concentration among NMP sites sampling PM_{10} metals. The annual average concentration of arsenic for PAFL is just greater than the program-level average concentration (0.67 ng/m^3).
- Figure 10-20 presents the box plot for fluoranthene for WPFL. This box plot shows that the maximum fluoranthene concentration measured across the program was measured at WPFL. The minimum fluoranthene concentration measured at WPFL (0.77 ng/m^3) is greater than the program-level first quartile. The annual average concentration for WPFL is twice the program-level average concentration. WPFL is one of only three NMP sites for which fluoranthene is a pollutant of interest.
- Figure 10-21 presents the box plot for fluorene for WPFL. This box plot shows that the maximum fluorene concentration measured at WPFL is considerably less than the maximum concentration measured across the program. Three non-detects of fluorene were measured at WPFL. The annual average concentration for WPFL is 1 ng/m^3 less than program-level average concentration.
- Figure 10-22 presents the box plots for formaldehyde for AZFL, ORFL, SKFL, and SYFL. The box plots show that the range of formaldehyde concentrations measured is smallest for SYFL and largest for ORFL. The maximum concentration measured at ORFL is more than twice the next highest formaldehyde concentration measured at a Florida site. All of the annual average concentrations calculated for the Florida sites for

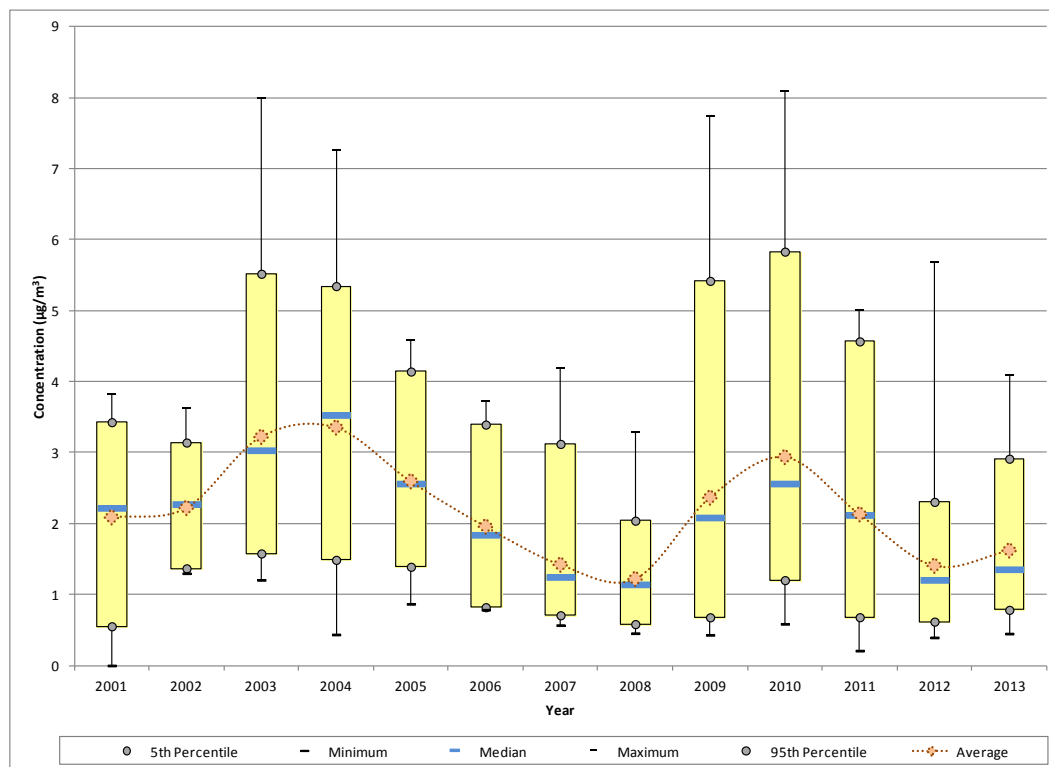
which formaldehyde is a pollutant of interest are less than the program-level average concentration as well as the program-level median concentration.

- Figure 10-23 presents the box plots for naphthalene for SKFL and WPFL. Although naphthalene was also sampled for at SYFL, sampling was discontinued at the end of June 2013 and thus, no annual average concentration could be calculated. This figure shows that although the range of concentrations measured was greater for WPFL, SKFL's annual average concentration ($69.26 \pm 13.80 \text{ ng/m}^3$) is nearly twice WPFL's ($35.74 \pm 33.34 \text{ ng/m}^3$). However, WPFL's period average is influenced by an outlier, as discussed in the previous section. Both averages, though, are less than the program-level average concentration.

10.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. AZFL, ORFL, SKFL, and SYFL have sampled carbonyl compounds under the NMP for at least 5 consecutive years; in addition, sampling for PAHs at SKFL and SYFL and PM_{10} metals at PAFL began in 2008. Thus, Figures 10-24 through 10-34 present the 1-year statistical metrics for each of the pollutants of interest for each of these Florida monitoring sites. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented. A trends analysis was not conducted for WPFL because this sampling at this site began in March 2013 and ended in March 2014.

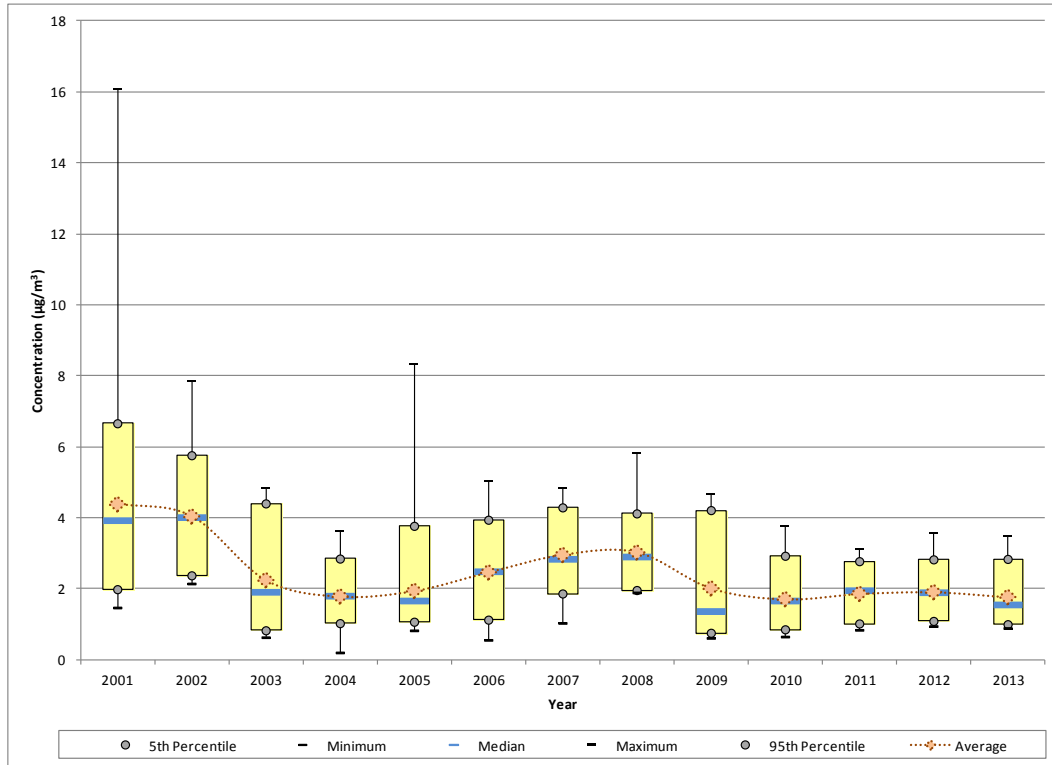
Figure 10-24. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at AZFL



Observations from Figure 10-24 for acetaldehyde measurements collected at AZFL include the following:

- Carbonyl compounds have been measured at AZFL under the NMP since 2001, making this site one of the longest running NMP sites.
- The maximum acetaldehyde concentration was measured in 2010 ($8.09 \mu\text{g}/\text{m}^3$), although similar concentrations were also measured in 2003 ($8.00 \mu\text{g}/\text{m}^3$) and 2009 ($7.74 \mu\text{g}/\text{m}^3$).
- The 1-year average and median concentrations did not change significantly during the first 2 years of sampling, although the range of measurements is twice as large for 2001 compared to 2002. The 1-year average and median concentrations increased significantly from 2002 to 2003, stayed elevated through 2004, then began to decrease significantly, a trend that continued through 2008.
- The 1-year average and median concentrations began to increase again in 2009. This increase cannot be attributed to an outlier here or there because nearly all of the statistical metrics exhibit this increase and the trend continued into 2010. The 95th percentile more than doubled from 2008 to 2009, and the 1-year average and median concentrations exhibit a similar increase. A significant decrease is shown for 2011 and continues into 2012, despite the increase in the maximum concentration measured in 2012. Slight increases in the central tendency statistics are shown for 2013, even though the range of measurements decreases.

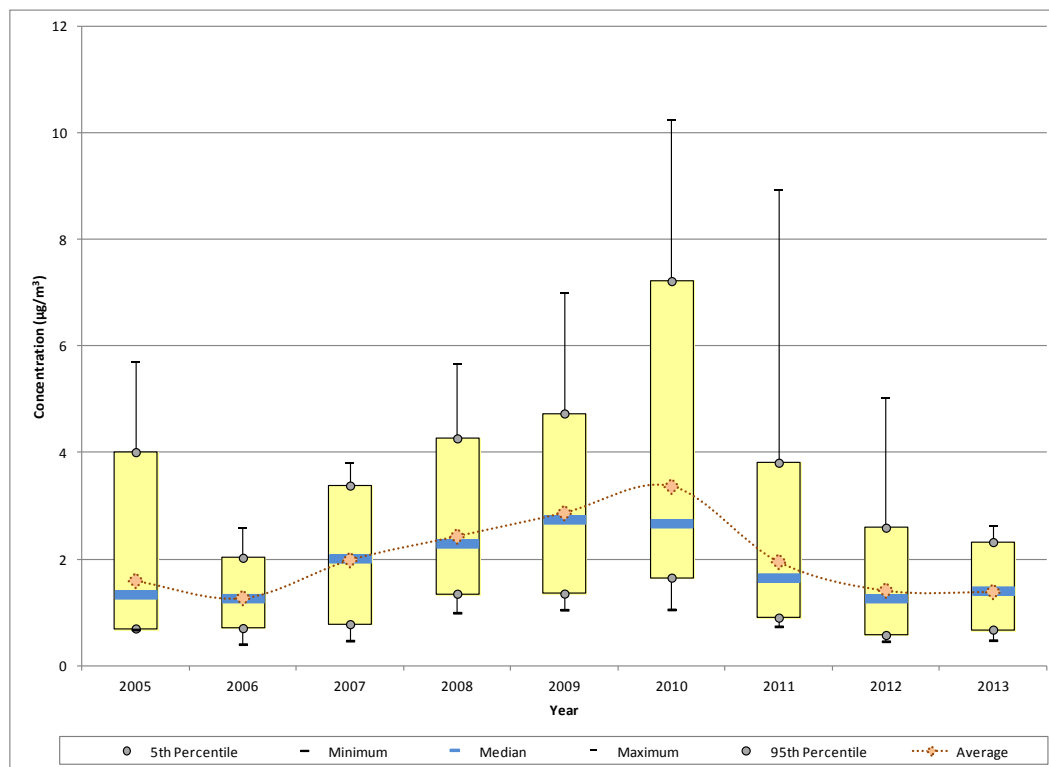
Figure 10-25. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at AZFL



Observations from Figure 10-25 for formaldehyde measurements collected at AZFL include the following:

- The maximum formaldehyde concentration was measured in 2001, after which the highest concentration measured in any given year decreased by nearly half. The three highest concentrations of formaldehyde (ranging from 9.30 µg/m³ to 16.1 µg/m³) were all measured in 2001.
- The 1-year average and median formaldehyde concentrations decreased significantly from 2002 to 2003. The decreasing trend continued through 2004, after which an increasing trend is shown, which lasted through 2008. A second significant decrease is shown from 2008 to 2009 and into 2010 (although the median concentration increased for 2010). Little change is shown for the last 3 years of sampling.
- The trends shown for formaldehyde in Figure 10-25 are almost the opposite of the trends shown for acetaldehyde in Figure 10-24, particularly for the period between 2004 through 2008.
- The difference between the 5th and 95th percentiles, the range within which the majority of the concentrations lie, is less than 2 µg/m³ between 2011 and 2013, indicating decreased variability in the measurements collected at AZFL compared to other years.

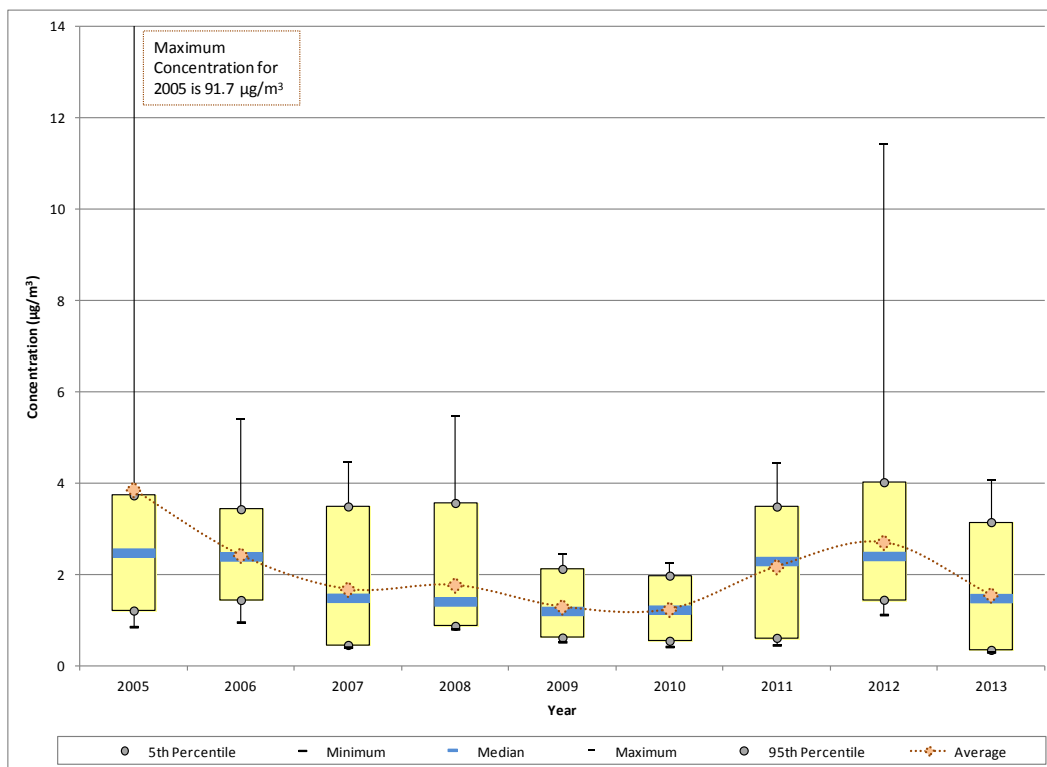
Figure 10-26. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at SKFL



Observations from Figure 10-26 for acetaldehyde measurements collected at SKFL include the following:

- Sampling for carbonyl compounds began at SKFL under the NMP in late July 2004. Because this represents less than half of the sampling year, Figure 10-26 excludes data from 2004.
- The maximum acetaldehyde concentration shown was measured in 2010 ($10.3 \mu\text{g}/\text{m}^3$). Although the second highest concentration was measured in 2011 ($8.94 \mu\text{g}/\text{m}^3$), the third, fourth, and fifth highest concentrations of acetaldehyde were also measured in 2010. Of the 18 acetaldehyde concentrations greater than $5 \mu\text{g}/\text{m}^3$, 11 were measured in 2010.
- Even though the range of concentrations measured decreased by half from 2005 to 2006, the change in the 1-year average concentration is not statistically significant. After 2006, the 1-year average acetaldehyde concentration increased steadily, reaching a maximum in 2010. A significant decrease is shown for 2011 and continues into 2012.
- Although the range of concentrations measured decreased by half for 2013, the 1-year average concentration changed little.

Figure 10-27. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at SKFL

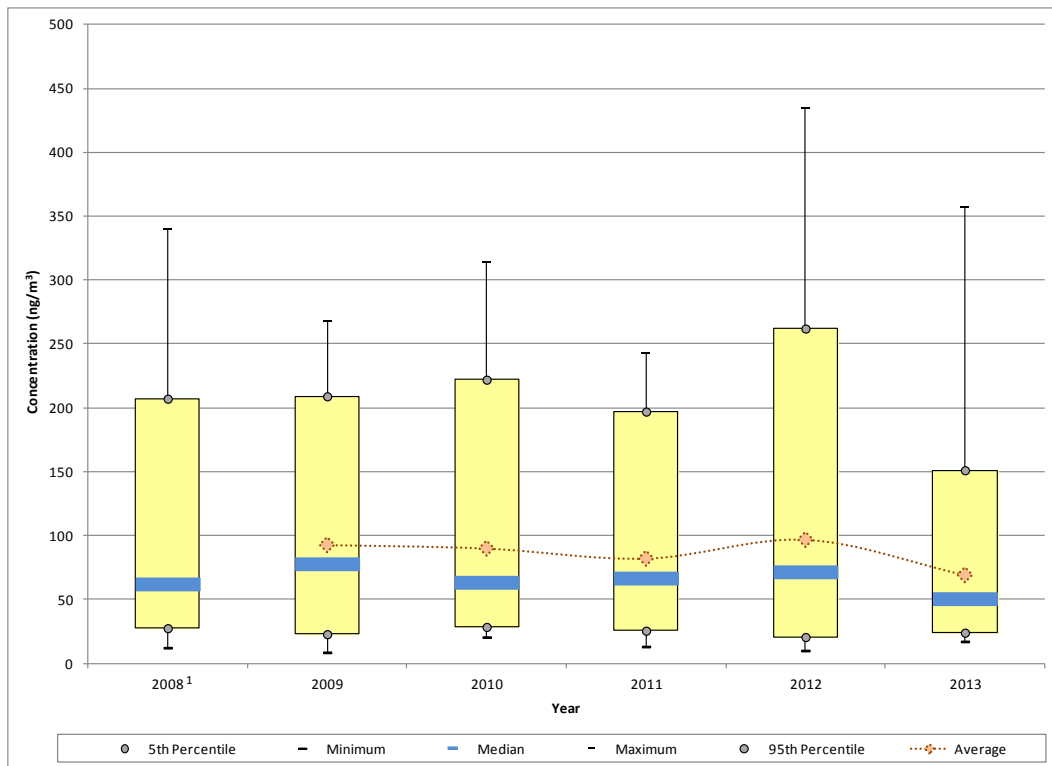


Observations from Figure 10-27 for formaldehyde measurements collected at SKFL include the following:

- The maximum formaldehyde concentration was measured at SKFL on July 9, 2005 ($91.7 \mu\text{g}/\text{m}^3$). The second highest formaldehyde concentration was measured at SKFL in 2012, but is considerably less ($11.4 \mu\text{g}/\text{m}^3$). No other concentrations greater than $6 \mu\text{g}/\text{m}^3$ have been measured at SKFL.
- For 2005, the 1-year average concentration is greater than the 95th percentile, reflecting the effect that an outlier can have on statistical measurements. The second highest concentration measured in 2005 was $4.07 \mu\text{g}/\text{m}^3$.
- The 1-year average and median concentrations exhibit a steady decreasing trend through 2010. The range of measurements is at a minimum for 2010 and the 1-year average and median concentration are nearly equivalent, reflecting little variability in the measurements.
- The range of concentrations measured increased significantly from 2010 to 2011 and the range within which the majority of the concentrations fall, as indicated by the difference between the 5th and 95th percentiles, more than doubled.
- All of the statistical parameters increased from 2011 to 2012, indicating that concentrations of formaldehyde were higher overall at SKFL for 2012. Conversely,

all of the statistical parameters exhibit a decrease for 2013. Both the minimum and 5th percentile are at a minimum for 2013.

Figure 10-28. Yearly Statistical Metrics for Naphthalene Concentrations Measured at SKFL



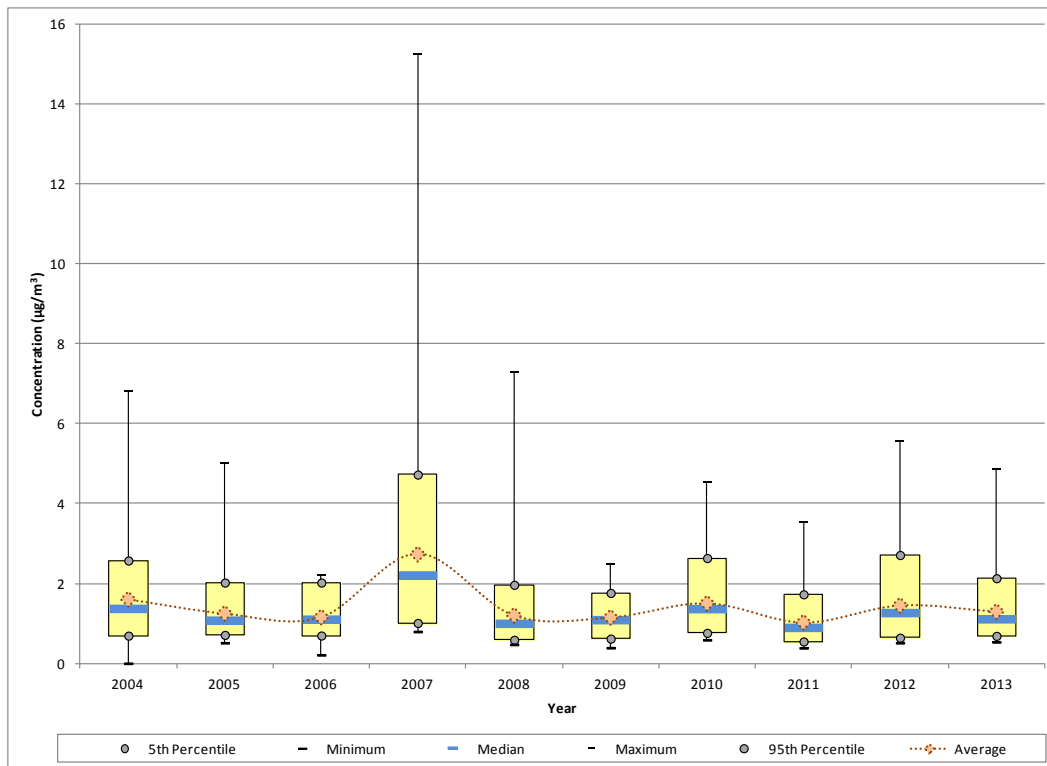
¹ A 1-year average is not presented because sampling under the NMP did not begin until March 2008.

Observations from Figure 10-28 for naphthalene measurements collected at SKFL include the following:

- Sampling for PAHs began at SKFL under the NMP in March 2008. A 1-year average concentration is not presented for 2008 because a full year's worth of data is not available, although the range of measurements is provided.
- The maximum naphthalene concentration was measured at SKFL in 2012 (435 ng/m³). Three additional measurements greater than 300 ng/m³ have been measured at SKFL (one each in 2008, 2010, and 2013).
- The range within which the majority of naphthalene concentrations fall changed little through 2011. There is an increase shown for 2012 as this year has the greatest number of measurements greater than 200 ng/m³ (seven). This increase is followed by a considerable decrease for 2013, which has the fewest measurements greater than 200 ng/m³ (one).
- Prior to 2013, the 1-year average concentrations ranged from 82.22 ng/m³ (2011) to 96.91 ng/m³ (2012). For 2013, the 1-year average concentration of naphthalene is at a

minimum (69.26 ng/m³). Confidence intervals calculated for these averages indicate that the year-to-year changes shown are not statistically significant.

Figure 10-29. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at SYFL

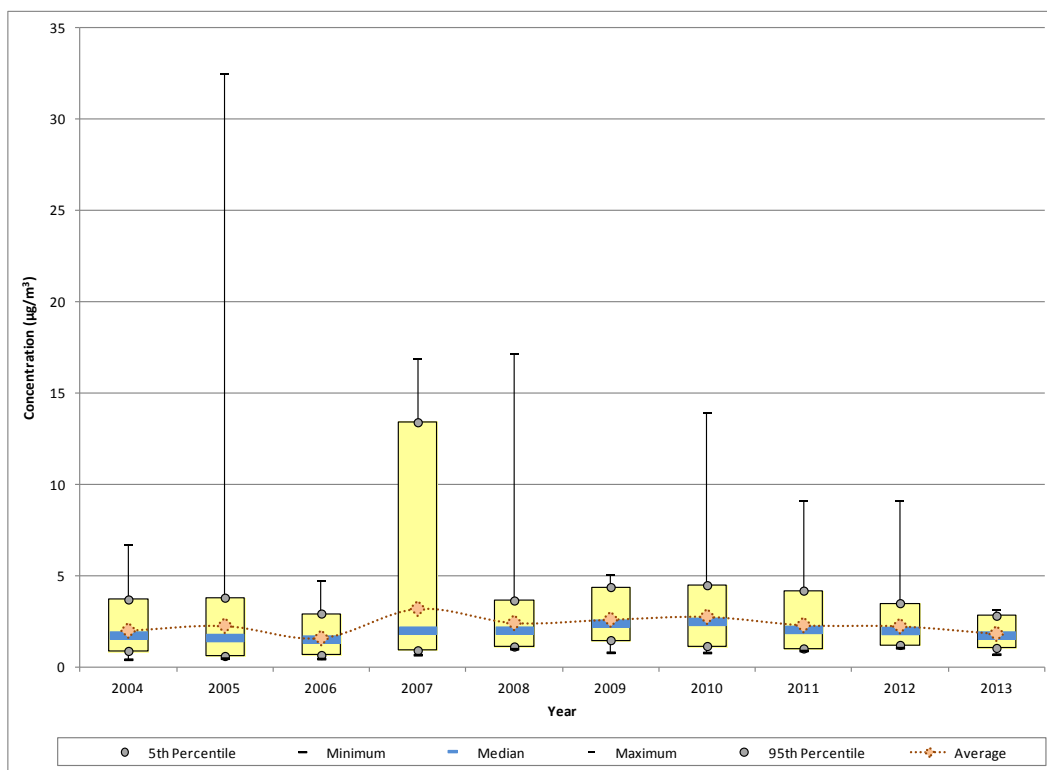


Observations from Figure 10-29 for acetaldehyde measurements collected at SYFL include the following:

- Carbonyl compounds have been measured at SYFL under the NMP since January 2004.
- The maximum acetaldehyde concentration was measured at SYFL on January 18, 2007 (15.3 µg/m³). The next highest concentration, also measured in 2007, is roughly half as high (7.55 µg/m³). Only one additional acetaldehyde measurement collected at SYFL is greater than 7 µg/m³ and was measured in 2008.
- After a decreasing trend through 2006, all of the statistical parameters increased for 2007. Even if the two measurements of acetaldehyde discussed above were removed from the calculation, the 1-year average concentration for 2007 is still 50 percent higher than the next highest 1-year average concentration. While every other year of sampling has three or less, 2007 has the greatest number of acetaldehyde concentrations greater than 3 µg/m³ (16). Thus, it is not just the two highest measurements driving this 1-year average concentration.

- With the exception of 2007, the 1-year average concentrations have fluctuated between $1.03 \mu\text{g}/\text{m}^3$ (2011) and $1.60 \mu\text{g}/\text{m}^3$ (2004). Confidence intervals calculated for the 1-year averages between 2009 and 2012 indicate that the year-to-year changes are statistically significant, although the undulating pattern indicates no specific trend. Though most of the statistics exhibit a slight decrease for 2013, the change is not significant.

Figure 10-30. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at SYFL

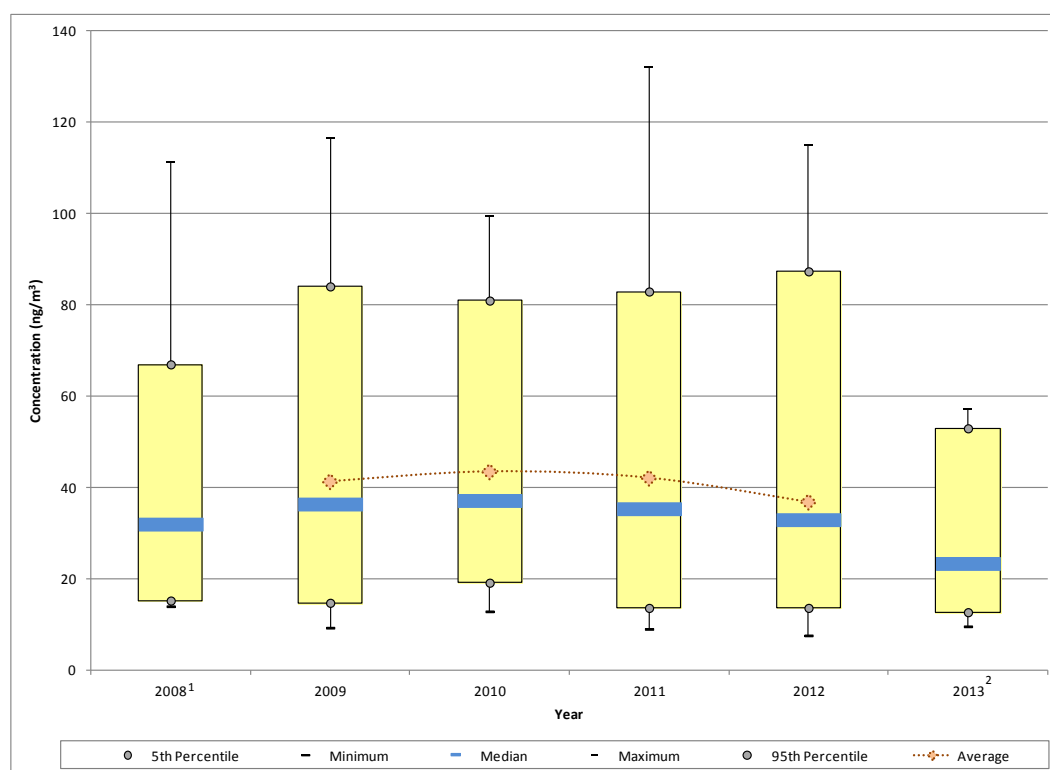


Observations from Figure 10-30 for formaldehyde measurements collected at SYFL include the following:

- The maximum formaldehyde concentration was measured at SYFL in 2005 ($32.5 \mu\text{g}/\text{m}^3$) and was nearly twice the next highest concentration ($17.1 \mu\text{g}/\text{m}^3$, measured in 2008), although several measurements of similar magnitude were also measured in 2007. In all, eight formaldehyde concentrations greater than $10 \mu\text{g}/\text{m}^3$ have been measured at SYFL, five in 2007 and one each in 2005, 2008, and 2010.
- Even though the maximum concentration was measured in 2005, the second highest concentration measured that year is considerably less ($4.17 \mu\text{g}/\text{m}^3$). The 1-year average concentration exhibits a slight increase from 2004 to 2005 while the median concentration decreased slightly. The outlier measured in 2005 is mostly reflected in the confidence intervals calculated for this 1-year average concentration.

- Although the maximum concentration for 2007 is considerably less than the maximum measured in 2005, the other statistical parameters exhibit significant increases. In particular, the 95th percentile increased four-fold and the 1-year average doubled from 2006 to 2007. These statistical parameters indicate that the measurements collected in 2007 were higher overall compared to other years. The number of formaldehyde concentrations greater than $5 \mu\text{g}/\text{m}^3$ is highest for 2007 (seven), while every other year of sampling has two or less.
- The 1-year average formaldehyde concentration has fluctuated over the years, ranging from $1.58 \mu\text{g}/\text{m}^3$ (2006) to $3.19 \mu\text{g}/\text{m}^3$ (2007). The 1-year average concentration for 2013 is the lowest since 2006 and has the smallest range of measurements of any year shown.

Figure 10-31. Yearly Statistical Metrics for Naphthalene Concentrations Measured at SYFL



¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

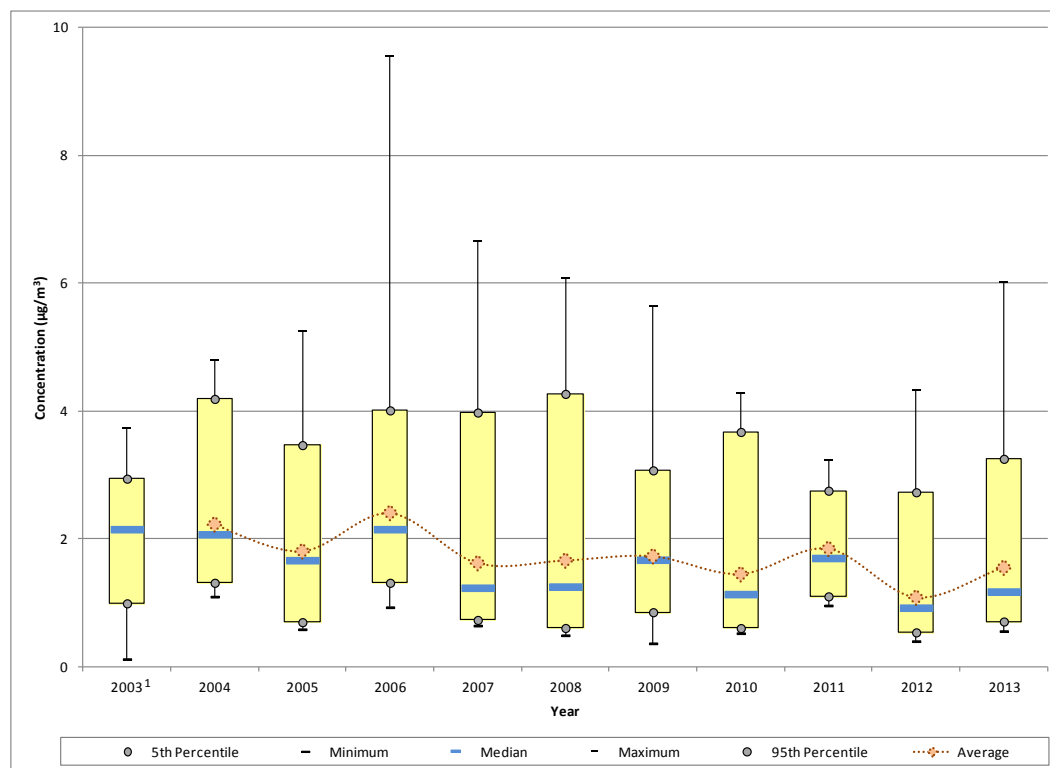
² PAH sampling was discontinued at SYFL in June 2013.

Observations from Figure 10-31 for naphthalene measurements collected at SYFL include the following:

- Sampling for PAHs began at SYFL under the NMP in April 2008. A 1-year average concentration is not presented for 2008 because a full year's worth of data is not available, although the range of measurements is provided. In addition, PAH sampling was discontinued at SYFL in June 2013; thus, a 1-year average concentration is not presented.

- The two highest naphthalene concentrations were both measured in 2011 (132 ng/m³ and 131 ng/m³), although measurements greater than 100 ng/m³ were also measured 2008, 2009, and 2012.
- The range within which the majority of naphthalene concentrations fall, as indicated by the difference between the 5th and 95th percentile for each year, changed little between 2009 and 2012. Although there is a slight increase shown for 2012, both the median and 1-year average concentrations exhibit slight decreases for 2012. This decrease is a result of a higher number of measurements at the lower end of the concentration range.
- The 1-year average concentrations have varied from 36.75 ng/m³ (2012) to 43.38 ng/m³ (2010) and confidence intervals calculated for these averages indicate that the changes over the years are not statistically significant.
- The range of concentrations measured decreased considerably for 2013, although only 6 months of measurements are included in the statistical metrics shown.

Figure 10-32. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at ORFL



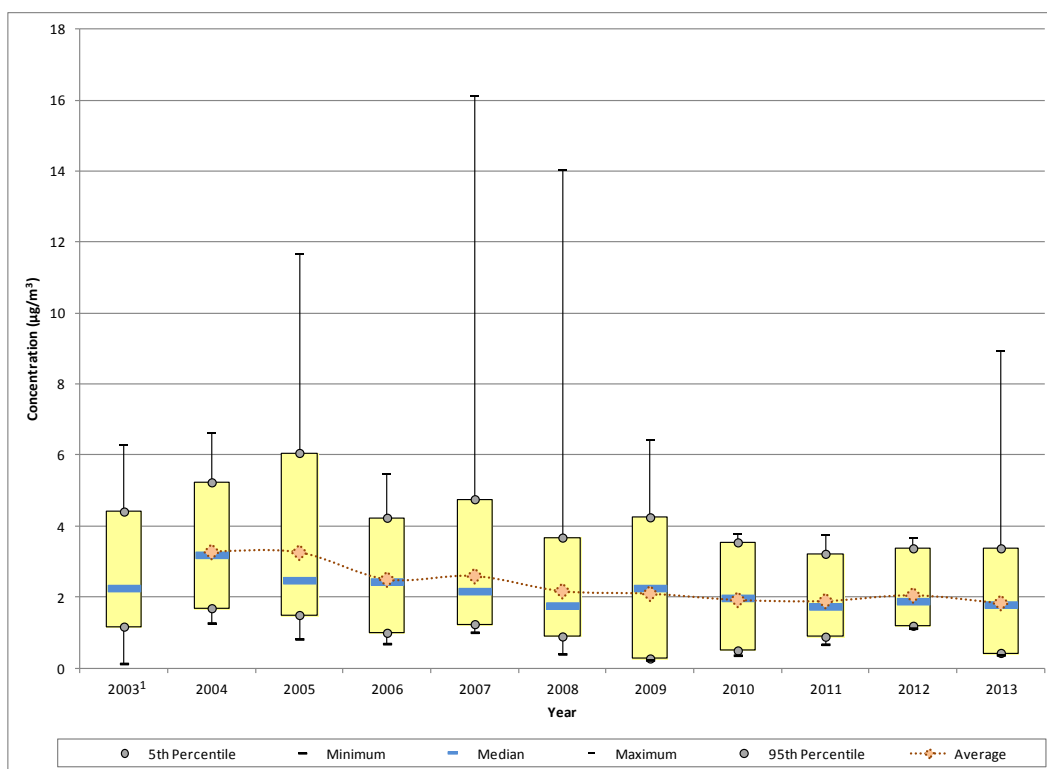
¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 10-32 for acetaldehyde measurements collected at ORFL include the following:

- Sampling for carbonyl compounds began at ORFL under the NMP in April 2003. A 1-year average concentration is not presented for 2003 because a full year's worth of data is not available, although the range of measurements is provided.

- The maximum acetaldehyde concentration was measured in 2006 ($9.55 \mu\text{g}/\text{m}^3$). The next three highest concentrations, each between $6 \mu\text{g}/\text{m}^3$ and $7 \mu\text{g}/\text{m}^3$, were measured in 2007, 2008, and 2013.
- Between 2004 and 2011, the 1-year average concentrations have varied by just less than $1 \mu\text{g}/\text{m}^3$, ranging from $1.45 \mu\text{g}/\text{m}^3$ (2010) to $2.41 \mu\text{g}/\text{m}^3$ (2006).
- The 1-year average concentration is at a minimum for 2012 ($1.08 \mu\text{g}/\text{m}^3$) and the median concentration decreased by almost half from 2011 to 2012. Only one concentration less than $1 \mu\text{g}/\text{m}^3$ was measured in 2011 compared to 38 for 2012 (and no other year has more than 30).
- All of the statistical metrics exhibit increases for 2013.

Figure 10-33. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at ORFL



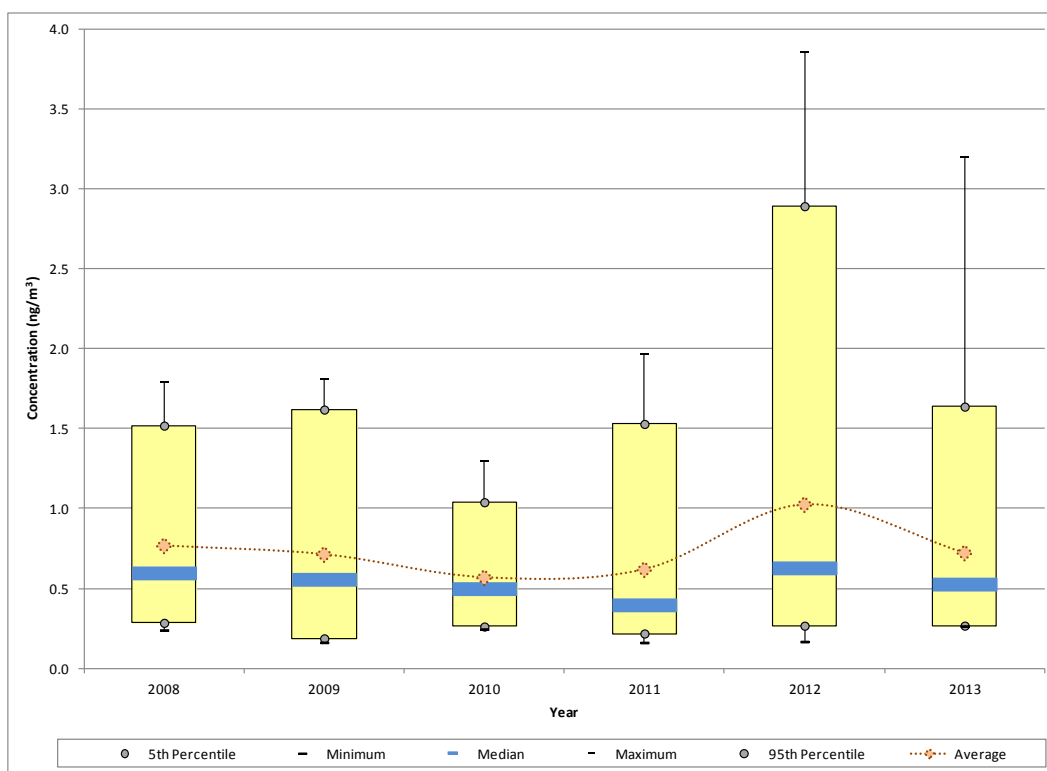
¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 10-33 for formaldehyde measurements collected at ORFL include the following:

- The maximum formaldehyde concentration was measured in 2007 ($16.1 \mu\text{g}/\text{m}^3$), although concentrations greater than $10 \mu\text{g}/\text{m}^3$ were also measured in 2005 and 2008.

- Even with the relatively high concentrations measured in the middle years of sampling, the 1-year average concentrations exhibit a steady decreasing trend through 2011, starting at 3.27 $\mu\text{g}/\text{m}^3$ for 2004 and reaching a minimum of 1.89 $\mu\text{g}/\text{m}^3$ for 2011. The median concentrations have decreased as well, but exhibited an increase in 2009, followed by additional decreases.
- The range of formaldehyde concentrations is at a minimum for 2012 and the maximum concentration for 2012 is the lowest maximum concentration shown for all years of sampling. Despite this, both the 1-year average and median concentrations increased slightly for 2012. Compared to 2011, concentrations measured in 2012 are higher overall. There are fewer measurements at the lower end of the concentration range for 2012, as there were no measurements less than 1 $\mu\text{g}/\text{m}^3$ measured in 2012 (compared to four in 2011). In addition, the number of measurements at the upper end of the concentration range for 2012 is higher, as the number of measurements greater than 3 $\mu\text{g}/\text{m}^3$ is nearly double for 2012 (9) than 2011 (5).
- Even though the maximum concentration more than doubled from 2012 to 2013 and the 95th percentile did not change, the remaining statistical parameters exhibit decreases for 2013. This is mostly due to a higher number of measurements at the lower end of the concentration range. The number of concentrations less than 1 $\mu\text{g}/\text{m}^3$ increased from none in 2012 to 13 in 2013.

Figure 10-34. Yearly Statistical Metrics for Arsenic (PM₁₀) Concentrations Measured at PAFL



Observations from Figure 10-34 for arsenic measurements collected at PAFL include the following:

- Four of the five arsenic concentrations greater than 2 ng/m³ were measured at PAFL in 2012, and ranged from 2.08 ng/m³ to 3.86 ng/m³. The fifth was measured on February 3, 2013 (3.20 ng/m³).
- The range of arsenic measurements collected is at a minimum for 2010, increases for 2011, then doubles for 2012. The range within which the majority of concentrations fall, indicated by the difference between the 5th and 95th percentiles, nearly doubles from 2010 to 2011 and again for 2012.
- The 1-year average concentration has a slight decreasing trend through 2010. After a slight increase for 2011, the 1-year average increases substantially for 2012. The median concentration exhibits a decreasing trend through 2011, even though the range of measurements increases for 2011, then increases for 2012.
- The number of measurements at the upper end of the concentration range has been increasing at PAFL since 2010, as the number of measurements greater than 1 ng/m³ increased from two in 2010 to five in 2011 to nine in 2012.
- With the exception of the minimum and 5th percentile, most of the statistical parameters exhibit a decrease from 2012 to 2013, with the 95th percentile decreasing by almost half from 2012 to 2013. The number of arsenic measurements greater than 1 ng/m³ returned to five in 2013.

10.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at each Florida monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

10.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Florida sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard

approximations are presented in Table 10-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 10-6. Risk Approximations for the Florida Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$)⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
St. Petersburg, Florida - AZFL						
Acetaldehyde	0.0000022	0.009	59/59	1.63 ± 0.19	3.58	0.18
Formaldehyde	0.000013	0.0098	59/59	1.77 ± 0.16	22.95	0.18
Pinellas Park, Florida - SKFL						
Acetaldehyde	0.0000022	0.009	60/60	1.39 ± 0.14	3.05	0.15
Formaldehyde	0.000013	0.0098	60/60	1.54 ± 0.24	20.03	0.16
Naphthalene ^a	0.000034	0.003	59/59	69.26 ± 13.80	2.35	0.02
Valrico, Florida - SYFL						
Acetaldehyde	0.0000022	0.009	61/61	1.30 ± 0.16	2.85	0.14
Formaldehyde	0.000013	0.0098	61/61	1.82 ± 0.14	23.69	0.19
Naphthalene ^a	0.000034	0.003	29/29	NA	NA	NA
Winter Park, Florida - ORFL						
Acetaldehyde	0.0000022	0.009	61/61	1.55 ± 0.28	3.41	0.17
Formaldehyde	0.000013	0.0098	61/61	1.84 ± 0.31	23.86	0.19
Orlando, Florida - PAFL						
Arsenic (PM ₁₀) ^a	0.0043	0.000015	30/30	0.72 ± 0.22	3.10	0.05
Belle Glade, Florida - WPFL¹						
Acenaphthene ^a	0.000088	--	30/30	4.62 ± 2.72	0.41	--
Fluoranthene ^a	0.000088	--	30/30	5.62 ± 3.64	0.49	--
Fluorene ^a	0.000088	--	27/30	3.66 ± 2.10	0.32	--
Naphthalene ^a	0.000034	0.003	30/30	35.74 ± 33.34	1.22	0.01

-- = A Cancer URE or Noncancer RfC is not available.

NA = Not available due to the criteria for calculating an annual average.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

¹Period averages are provided for WPFL.

Observations for the Florida sites from Table 10-6 include the following:

- Formaldehyde has the highest cancer risk approximations among the various pollutants of interest for the Florida sites. These cancer risk approximations span a relatively small range (20.03 in-a-million for SKFL to 23.86 in-a-million for ORFL).
- The cancer risk approximations for acetaldehyde are an order of magnitude less than the cancer risk approximations for formaldehyde, ranging from 2.85 in-a-million for SYFL to 3.58 in-a-million for AZFL.
- For PAFL, arsenic has a cancer risk approximation of 3.10 in-a-million.
- For the sites sampling naphthalene, the cancer risk approximations range from 1.22 in-a-million (WPFL) to 2.35 in-a-million (SKFL). As previously discussed, an annual average concentration, and therefore cancer risk and noncancer hazard approximations, could not be calculated for SYFL for naphthalene.
- The cancer risk approximations for WPFL's remaining PAH pollutants of interest are all less than 1 in-a-million.
- All of the noncancer hazard approximations for the site-specific pollutants of interest are less than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The highest noncancer hazard approximation was calculated for formaldehyde (0.19), based on the annual average concentration for SYFL and ORFL.

10.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, Tables 10-7 and 10-8 present an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 10-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 10-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 10-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 10-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 10-7. Table 10-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 10-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Florida Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
St. Petersburg, Florida (Pinellas County) - AZFL					
Benzene	423.95	Benzene	3.31E-03	Formaldehyde	22.95
Ethylbenzene	262.81	Formaldehyde	2.68E-03	Acetaldehyde	3.58
Formaldehyde	206.42	1,3-Butadiene	1.77E-03		
Acetaldehyde	133.62	Naphthalene	6.91E-04		
1,3-Butadiene	58.94	Ethylbenzene	6.57E-04		
Naphthalene	20.33	POM, Group 2b	3.19E-04		
Dichloromethane	3.85	Acetaldehyde	2.94E-04		
POM, Group 2b	3.63	POM, Group 2d	2.68E-04		
POM, Group 2d	3.04	Arsenic, PM	2.28E-04		
Tetrachloroethylene	1.67	Nickel, PM	1.48E-04		
Pinellas Park, Florida (Pinellas County) - SKFL					
Benzene	423.95	Benzene	3.31E-03	Formaldehyde	20.03
Ethylbenzene	262.81	Formaldehyde	2.68E-03	Acetaldehyde	3.05
Formaldehyde	206.42	1,3-Butadiene	1.77E-03	Naphthalene	2.35
Acetaldehyde	133.62	Naphthalene	6.91E-04		
1,3-Butadiene	58.94	Ethylbenzene	6.57E-04		
Naphthalene	20.33	POM, Group 2b	3.19E-04		
Dichloromethane	3.85	Acetaldehyde	2.94E-04		
POM, Group 2b	3.63	POM, Group 2d	2.68E-04		
POM, Group 2d	3.04	Arsenic, PM	2.28E-04		
Tetrachloroethylene	1.67	Nickel, PM	1.48E-04		

Table 10-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Florida Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Valrico, Florida (Hillsborough County) - SYFL					
Benzene	439.99	Formaldehyde	3.47E-03	Formaldehyde	23.69
Ethylbenzene	294.34	Benzene	3.43E-03	Acetaldehyde	2.85
Formaldehyde	266.66	1,3-Butadiene	1.89E-03		
Acetaldehyde	166.39	Nickel, PM	1.47E-03		
1,3-Butadiene	63.16	Cadmium, PM	1.37E-03		
Naphthalene	27.75	Arsenic, PM	1.23E-03		
Methyl <i>tert</i> -butyl ether	7.67	Naphthalene	9.43E-04		
POM, Group 2b	5.34	Ethylbenzene	7.36E-04		
POM, Group 2d	4.24	Hexavalent Chromium	6.15E-04		
Nickel, PM	3.07	POM, Group 2b	4.70E-04		
Winter Park, Florida (Orange County) - ORFL					
Benzene	557.93	Hexavalent Chromium	5.22E-03	Formaldehyde	23.86
Formaldehyde	373.01	Formaldehyde	4.85E-03	Acetaldehyde	3.41
Ethylbenzene	343.02	Benzene	4.35E-03		
Acetaldehyde	198.71	1,3-Butadiene	2.41E-03		
1,3-Butadiene	80.46	Naphthalene	1.03E-03		
Naphthalene	30.26	Ethylbenzene	8.58E-04		
POM, Group 2b	6.43	POM, Group 2b	5.65E-04		
POM, Group 2d	4.63	Acetaldehyde	4.37E-04		
Tetrachloroethylene	2.91	POM, Group 2d	4.08E-04		
Dichloromethane	1.09	Arsenic, PM	3.86E-04		

Table 10-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Florida Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Orlando, Florida (Orange County) - PAFL					
Benzene	557.93	Hexavalent Chromium	5.22E-03	Arsenic	3.10
Formaldehyde	373.01	Formaldehyde	4.85E-03		
Ethylbenzene	343.02	Benzene	4.35E-03		
Acetaldehyde	198.71	1,3-Butadiene	2.41E-03		
1,3-Butadiene	80.46	Naphthalene	1.03E-03		
Naphthalene	30.26	Ethylbenzene	8.58E-04		
POM, Group 2b	6.43	POM, Group 2b	5.65E-04		
POM, Group 2d	4.63	Acetaldehyde	4.37E-04		
Tetrachloroethylene	2.91	POM, Group 2d	4.08E-04		
Dichloromethane	1.09	Arsenic, PM	3.86E-04		
Belle Glade, Florida (Palm Beach County) - WPFL					
Formaldehyde	955.60	Formaldehyde	1.24E-02	Naphthalene	1.22
Benzene	643.30	Naphthalene	1.10E-02	Fluoranthene	0.49
Acetaldehyde	441.40	Benzene	5.02E-03	Acenaphthene	0.41
Ethylbenzene	326.91	1,3-Butadiene	4.13E-03	Fluorene	0.32
Naphthalene	322.43	Acetaldehyde	9.71E-04		
1,3-Butadiene	137.62	Ethylbenzene	8.17E-04		
POM, Group 2d	8.01	POM, Group 2d	7.05E-04		
POM, Group 2b	7.49	POM, Group 2b	6.60E-04		
Tetrachloroethylene	4.71	Arsenic, PM	5.84E-04		
Dichloromethane	3.63	Nickel, PM	5.20E-04		

Table 10-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Florida Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
St. Petersburg, Florida (Pinellas County) - AZFL					
Toluene	1,691.40	Acrolein	529,170.22	Formaldehyde	0.18
Xylenes	1,112.81	1,3-Butadiene	29,468.37	Acetaldehyde	0.18
Hexane	837.02	Formaldehyde	21,063.17		
Methanol	533.81	Acetaldehyde	14,846.98		
Benzene	423.95	Benzene	14,131.55		
Ethylbenzene	262.81	Xylenes	11,128.12		
Formaldehyde	206.42	Naphthalene	6,776.34		
Ethylene glycol	183.89	Lead, PM	4,834.15		
Acetaldehyde	133.62	Arsenic, PM	3,541.06		
Methyl isobutyl ketone	85.23	Nickel, PM	3,431.37		
Pinellas Park, Florida (Pinellas County) - SKFL					
Toluene	1,691.40	Acrolein	529,170.22	Formaldehyde	0.16
Xylenes	1,112.81	1,3-Butadiene	29,468.37	Acetaldehyde	0.15
Hexane	837.02	Formaldehyde	21,063.17	Naphthalene	0.02
Methanol	533.81	Acetaldehyde	14,846.98		
Benzene	423.95	Benzene	14,131.55		
Ethylbenzene	262.81	Xylenes	11,128.12		
Formaldehyde	206.42	Naphthalene	6,776.34		
Ethylene glycol	183.89	Lead, PM	4,834.15		
Acetaldehyde	133.62	Arsenic, PM	3,541.06		
Methyl isobutyl ketone	85.23	Nickel, PM	3,431.37		

Table 10-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Florida Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Valrico, Florida (Hillsborough County) - SYFL					
Toluene	1,908.71	Acrolein	839,881.94	Formaldehyde	0.19
Xylenes	1,141.28	Cadmium, PM	76,216.14	Acetaldehyde	0.14
Hexane	974.23	Nickel, PM	34,087.06		
Methanol	723.09	1,3-Butadiene	31,578.65		
Benzene	439.99	Formaldehyde	27,210.45		
Hydrochloric acid	356.26	Arsenic, PM	19,144.38		
Ethylbenzene	294.34	Acetaldehyde	18,488.27		
Ethylene glycol	287.12	Hydrochloric acid	17,813.03		
Formaldehyde	266.66	Benzene	14,666.49		
Acetaldehyde	166.39	Xylenes	11,412.81		
Winter Park, Florida (Orange County) - ORFL					
Toluene	2,144.16	Acrolein	1,048,114.49	Formaldehyde	0.19
Xylenes	1,437.17	1,3-Butadiene	40,232.28	Acetaldehyde	0.17
Hexane	985.39	Formaldehyde	38,061.79		
Methanol	678.41	Hexamethylene-1,6-diisocyanate, gas	30,043.31		
Benzene	557.93	Acetaldehyde	22,079.12		
Formaldehyde	373.01	Benzene	18,597.79		
Ethylbenzene	343.02	Xylenes	14,371.73		
Ethylene glycol	268.80	Naphthalene	10,085.90		
Acetaldehyde	198.71	Arsenic, PM	5,985.06		
Styrene	101.41	Hydrochloric acid	4,682.79		

Table 10-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Florida Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Orlando, Florida (Orange County) - PAFL					
Toluene	2,144.16	Acrolein	1,048,114.49	Arsenic	0.05
Xylenes	1,437.17	1,3-Butadiene	40,232.28		
Hexane	985.39	Formaldehyde	38,061.79		
Methanol	678.41	Hexamethylene-1,6-diisocyanate, gas	30,043.31		
Benzene	557.93	Acetaldehyde	22,079.12		
Formaldehyde	373.01	Benzene	18,597.79		
Ethylbenzene	343.02	Xylenes	14,371.73		
Ethylene glycol	268.80	Naphthalene	10,085.90		
Acetaldehyde	198.71	Arsenic, PM	5,985.06		
Styrene	101.41	Hydrochloric acid	4,682.79		
Belle Glade, Florida (Palm Beach County) - WPFL					
Toluene	2,191.25	Acrolein	1,137,704.46	Naphthalene	0.01
Xylenes	1,392.77	Naphthalene	107,477.97		
Hexane	977.01	Formaldehyde	97,510.06		
Formaldehyde	955.60	1,3-Butadiene	68,809.22		
Methanol	902.57	Chlorine	60,272.30		
Benzene	643.30	Acetaldehyde	49,044.32		
Acetaldehyde	441.40	Benzene	21,443.18		
Ethylbenzene	326.91	Xylenes	13,927.73		
Naphthalene	322.43	Nickel, PM	12,047.05		
Ethylene glycol	262.17	Manganese, PM	10,798.23		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 10.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 10-7 include the following:

- Benzene, ethylbenzene, formaldehyde, and acetaldehyde are the highest emitted pollutants with cancer UREs in Pinellas, Hillsborough, Orange, and Palm Beach Counties, although not necessarily in that order.
- Benzene, formaldehyde, and 1,3-butadiene have the highest toxicity-weighted emissions for Pinellas County. The same three pollutants have the highest toxicity-weighted emissions for Hillsborough County but the order is different. Hexavalent chromium has the highest toxicity-weighted emissions for Orange County, followed by the other three pollutants. Formaldehyde and naphthalene have the highest toxicity-weighted emissions for Palm Beach County, followed by benzene and 1,3-butadiene.
- Eight of the highest emitted pollutants in Pinellas, Orange, and Palm Beach Counties also have the highest toxicity-weighted emissions while seven of the highest emitted pollutants in Hillsborough County also have the highest toxicity-weighted emissions.
- Formaldehyde, which has the highest cancer risk approximations for all sites sampling carbonyl compounds, is one of the highest emitted pollutants in each county and has one of the highest toxicity-weighted emissions for each county. This is also true for acetaldehyde for Pinellas, Orange, and Palm Beach Counties, but acetaldehyde does not appear among those pollutants with the highest toxicity-weighted emissions for Hillsborough County (it ranks 12th).
- Naphthalene, which is a pollutant of interest for SFKL, SYFL, and WPFL, is one of the highest emitted pollutants in all three counties and has one of the highest toxicity-weighted emissions for each county. Naphthalene ranks second highest for toxicity-weighted emissions for Palm Beach County, one of only two counties with NMP sites where naphthalene ranks this high.
- Arsenic is the only pollutant of interest for PAFL. Arsenic ranks 10th for toxicity-weighted emissions for Orange County, but is not among the highest emitted pollutants, ranking 23rd for quantity emitted. This is an indication of the relative

toxicity of even a low quantity of emissions. Arsenic appears among those with the highest toxicity-weighted emissions for all four Florida counties with NMP sites.

- Fluoranthene, acenaphthene, and fluorene are pollutants of interest for WPFL. These pollutants are part of POM, Group 2b. POM Group 2b appears on both emissions-based lists for Palm Beach County, ranking eighth for total emissions and seventh for toxicity-weighted emissions. POM, Group 2b appears on both emissions-based lists for all four Florida counties with NMP sites.
- POM, Group 2d is also among the highest emitted “pollutants” in all four counties and appears among the pollutants with the highest toxicity-weighted emissions for three of the four counties. POM, Group 2d includes several PAHs sampled for at SKFL, SYFL, and WPFL including anthracene, phenanthrene, and pyrene, none of which failed screens for these sites.

Observations from Table 10-8 include the following:

- Toluene, xylenes, and hexane are the highest emitted pollutants with noncancer RfCs in all four Florida counties.
- Acrolein has the highest toxicity-weighted emissions of the pollutants with noncancer RfCs for each county, but is not among the highest emitted pollutants in the four Florida counties. None of the Florida sites sampled VOCs under the NMP.
- Four of the highest emitted pollutants in Pinellas and Orange Counties also have the highest toxicity-weighted emissions. Five of the highest emitted pollutants in Hillsborough and Palm Beach Counties also have the highest toxicity-weighted emissions. Four of these pollutants are in common amongst the counties: formaldehyde, acetaldehyde, benzene, and xylenes.
- Formaldehyde and acetaldehyde appear on both emissions-based lists for each county. Naphthalene is among the pollutants with the highest toxicity-weighted emissions for each county (except Hillsborough County) but is not among the highest emitted (with a noncancer RfC) in any of the counties except Palm Beach County. For Palm Beach County, naphthalene ranks second highest behind acrolein for toxicity-weighted emissions, its highest ranking among counties with NMP sites, and ranks ninth highest for its total emissions. Compared to other counties with NMP sites, Palm Beach County has the highest naphthalene emissions, which are more than twice the next highest emissions (Los Angeles County).
- Several metals appear among those pollutants with the highest toxicity-weighted emissions for each Florida county, ranking highest for Hillsborough County, but these metals are not among the highest emitted. Metals were sampled for only at PAFL under the NMP. Arsenic is the only metal that appears among the pollutants with the highest toxicity-weighted emissions for Orange County (ranking ninth).

10.6 Summary of the 2013 Monitoring Data for the Florida Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *Acetaldehyde and formaldehyde failed screens for AZFL and ORFL, where only carbonyl compounds were sampled. Four pollutants (formaldehyde, acetaldehyde, naphthalene, and hexavalent chromium) failed screens for SKFL. Three pollutants (formaldehyde, acetaldehyde, naphthalene) failed screens for SYFL. Arsenic failed screens for PAFL. Four PAHs failed screens for WPFL.*
- ❖ *Concentrations of acetaldehyde and formaldehyde did not vary significantly among the Florida sites where carbonyl compounds were sampled. The annual average concentration of naphthalene for SKFL was nearly twice the annual average concentration for WPFL, the two sites where annual average concentrations of naphthalene could be calculated. Arsenic was the only metals identified as a pollutant of interest for PAFL; its annual average ranked sixth highest among NMP sites sampling PM₁₀ metals.*
- ❖ *After several years of decreasing, concentrations of acetaldehyde appear to be leveling off at SKFL while concentrations of formaldehyde appear to be decreasing. Formaldehyde concentrations measured in 2013 at SYFL exhibit the least amount of variability over the 10 years of sampling.*
- ❖ *Formaldehyde has the highest cancer risk approximation among the pollutants of interest for each Florida site, where carbonyl compounds were sampled. None of the pollutants of interest have noncancer hazard approximations greater than an HQ of 1.0.*

11.0 Site in Georgia

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Georgia, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

11.1 Site Characterization

This section characterizes the SDGA monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The SDGA monitoring site is located in Decatur, Georgia, a suburb of Atlanta. Figure 11-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 11-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 11-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 11-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 11-1. Decatur, Georgia (SDGA) Monitoring Site

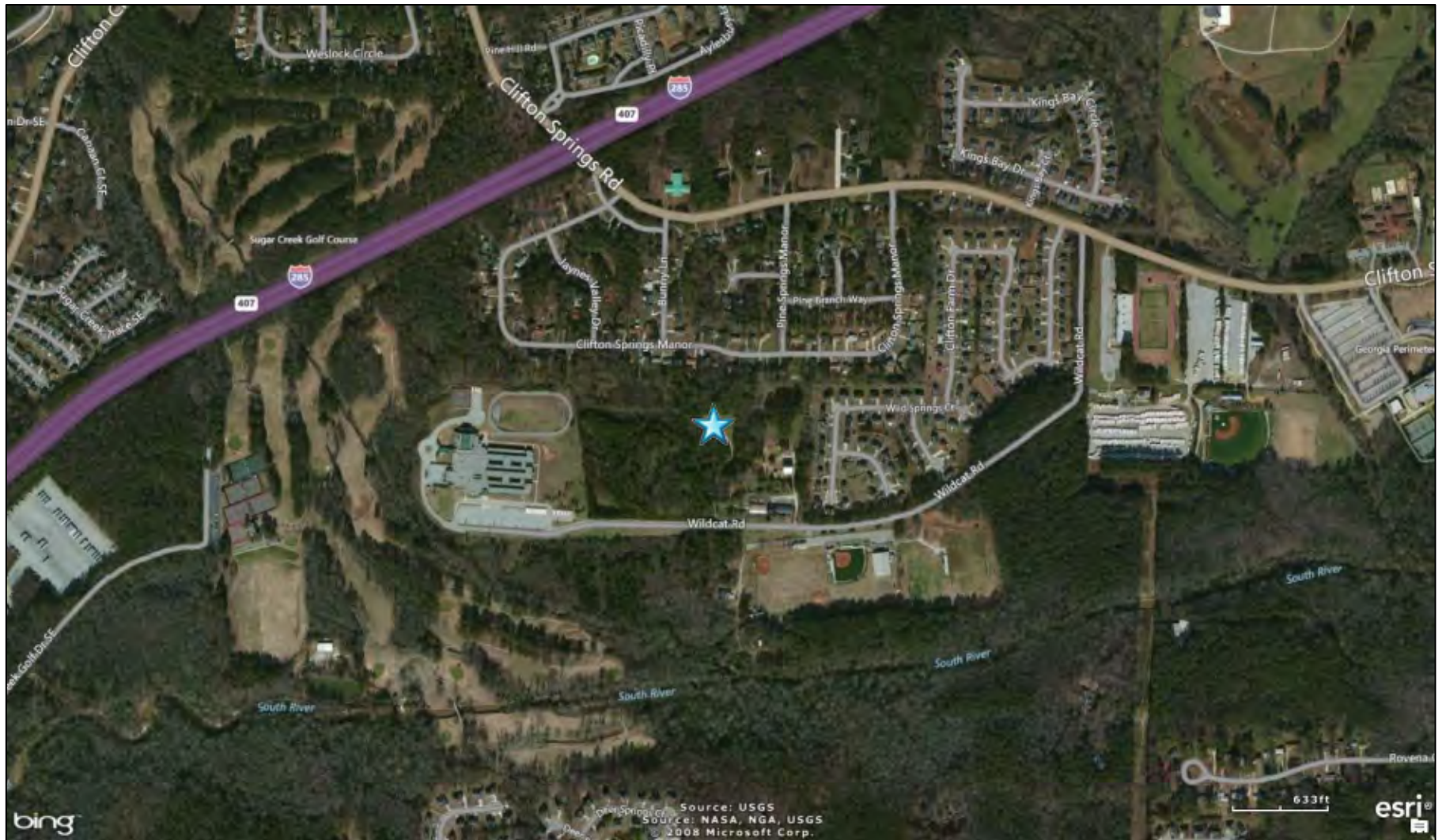


Figure 11-2. NEI Point Sources Located Within 10 Miles of SDGA

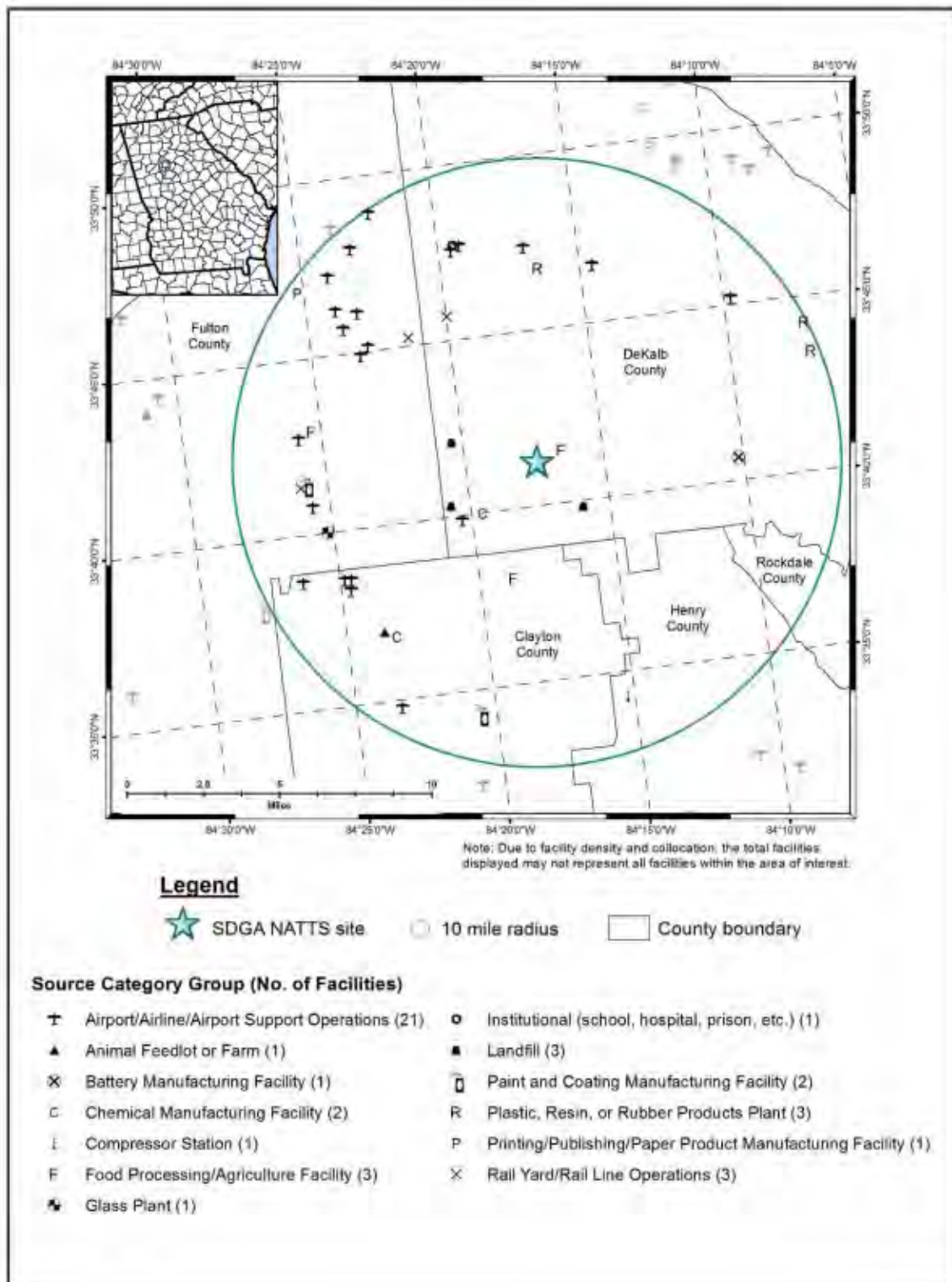


Table 11-1. Geographical Information for the Georgia Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>SDGA</i>	13-089-0002	Decatur	DeKalb	Atlanta-Sandy Springs-Roswell, GA	33.68797, -84.29048	Residential	Suburban	CO, SO ₂ , NO _y , NO, NO ₂ , NO _x , PAMS, Carbonyl compounds, VOCs, O ₃ , Meteorological parameters, PM ₁₀ , PM Coarse, PM ₁₀ Speciation, Black carbon, PM _{2.5} , and PM _{2.5} Speciation, Haze, IMPROVE Speciation, SNMOC

¹Data for additional pollutants are reported to AQS for this site (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

SDGA is located on the DeKalb County Schools Environmental Education property off Wildcat Road and is the South DeKalb NATTS site. Residential subdivisions, a greenhouse and horse barn, athletic fields, and a middle school surround the monitoring site. A golf course backs up against the school property on the south and east sides. Interstate-285 is located about one-half mile north of the site, as shown in Figure 11-1. As Figure 11-2 shows, only one point source (a food processing facility) is located in close proximity to SDGA. Additional point sources are located primarily on the west side of the 10-mile radius. The airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations, is the source category with the greatest number of emissions sources within 10 miles of SDGA.

Table 11-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Georgia monitoring site. Table 11-2 includes both county-level population and vehicle registration information. Table 11-2 also contains traffic volume information for SDGA as well as the location for which the traffic volume was obtained. Additionally, Table 11-2 presents the county-level daily VMT for DeKalb County.

Table 11-2. Population, Motor Vehicle, and Traffic Information for the Georgia Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
<i>SDGA</i>	DeKalb	713,340	479,533	138,470	I-285, north of Clifton Springs Rd	20,900,748

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2013 data (GA DOR, 2013)

³AADT reflects 2012 data (GA DOT, 2012)

⁴County-level VMT reflects 2013 data (GA DOT, 2013)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 11-2 include the following:

- SDGA's county-level population and vehicle registration are in the middle of the range compared to other counties with NMP sites.
- The traffic volume experienced near SDGA ranks eighth highest compared to other NMP sites. The traffic estimate provided is for I-285, north of Clifton Springs Road.
- The daily VMT for DeKalb County is in the top third compared to other counties with NMP sites.

11.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Georgia on sample days, as well as over the course of the year.

11.2.1 Climate Summary

Atlanta is the largest city in Georgia and is located at the base of the Blue Ridge Mountains. The Gulf of Mexico to the south is the major moisture source for weather systems that move across the region. These topographical features, in addition to the Atlantic Ocean to the east, exert moderating influences on the area's climate, tempering cold air outbreaks from the north as well as summer heat waves. Summers are warm and humid while winters are relatively mild, although snow is not uncommon. The semi-permanent Bermuda High Pressure over the Atlantic Ocean is a dominant weather feature affecting the Atlanta area, which pulls warm, moist air into the region. Precipitation is plentiful. Although autumn is the driest season, monthly rainfall generally ranges between 3 inches and 5 inches. Westerly and northwesterly winds prevail throughout much of the year, although east winds tend to be more common in the late summer and fall (Wood, 2004; GSCO, 1998; NCDC, 2015).

11.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Georgia monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station to SDGA is located at W. B. Hartsfield/Atlanta International Airport (WBAN 13874). Additional information about the Hartsfield Airport weather station, such as the distance between the site and the weather station, is provided in Table 11-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 11-3. Average Meteorological Conditions near the Georgia Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Decatur, Georgia - SDGA									
W.B. Hartsfield/Atlanta Intl. Airport 13874 (33.63, -84.44)	9.6 miles 245° (WSW)	Sample Days (33)	70.0 ± 4.3	61.5 ± 4.6	49.4 ± 5.5	55.2 ± 4.5	67.5 ± 5.2	1018.5 ± 1.7	7.4 ± 0.9
		2013	70.3 ± 1.4	61.7 ± 1.4	50.1 ± 1.7	55.7 ± 1.4	68.5 ± 1.5	1018.8 ± 0.5	6.8 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 11-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 11-3 is the 95 percent confidence interval for each parameter. As shown in Table 11-3, average meteorological conditions on sample days near SDGA were representative of average weather conditions experienced throughout the year. This is true even though sampling was discontinued at SDGA in mid-July 2013 and the sample day averages shown in Table 11-3 include only 7 months of sample days.

11.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at Hartsfield International Airport near SDGA were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

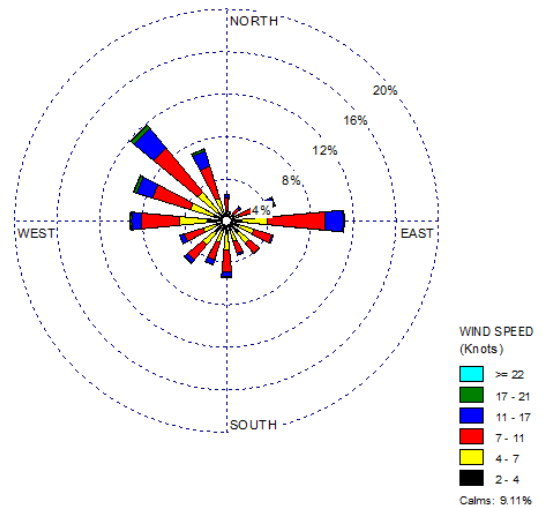
Figure 11-5 presents a map showing the distance between the weather station and SDGA, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 11-5 also presents three different wind roses for the SDGA monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 11-3. Wind Roses for the Hartsfield International Airport Weather Station near SDGA

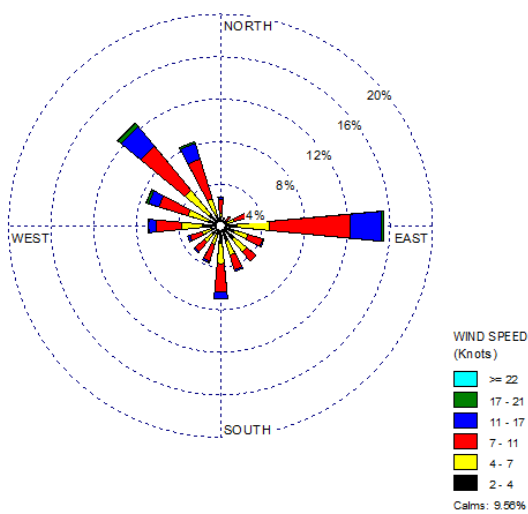
Location of SDGA and Weather Station



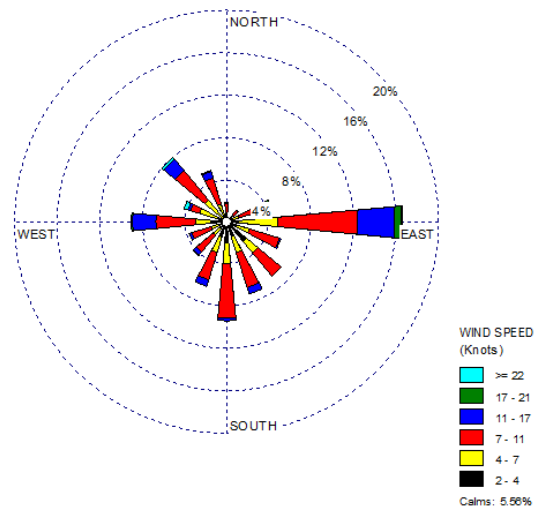
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 11-5 for SDGA include the following:

- The weather station at Hartsfield International Airport is the closest weather station to SDGA and is located 9.6 miles west-southwest of SDGA.
- The historical wind rose shows that winds from the west to north-northwest account for nearly 40 percent of wind observations, with northwesterly winds observed the most. Easterly winds were also common and account for the second highest percentage of observations. Winds from the north to northeast were rarely observed. Calm winds (less than or equal to 2 knots) were observed for less than 10 percent of the hourly wind measurements.
- The wind patterns on the full-year wind rose are similar to those of the historical wind rose, although winds from the east and northwest account for a higher percentage of wind observations, particularly east winds, which account for nearly 16 percent of observations in 2013.
- Easterly winds were prevalent on sample days, as shown on the sample day wind rose, accounting for more than 16 percent of wind observations. Although west-northwesterly to north-northwesterly winds were observed, the percentage is considerably reduced, while westerly winds account for a greater percentage of observations on the sample day wind rose compared to the full-year wind rose. Winds from the southeast and southwest quadrants also account for a greater percentage of wind observations near SDGA. Finally, the percentage of calm winds on sample days is reduced by nearly half. Recall, though, that sampling was discontinued in July at SDGA; thus, a wind rose for a full year of sample days may look different.

11.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for SDGA in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 11-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 11-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Hexavalent chromium was sampled for at SDGA, although sampling was discontinued at SDGA in mid-July.

Table 11-4. Risk-Based Screening Results for the Georgia Monitoring Site

Pollutant	Screening Value ($\mu\text{g}/\text{m}^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Decatur, Georgia - SDGA						
Hexavalent Chromium	0.000083	1	8	12.50	100.00	100.00
Total		1	8	12.50		

Observations from Table 11-4 for SDGA include the following:

- Thirty valid hexavalent chromium samples were collected at SDGA between January 4, 2013 and July 15, 2013, in which hexavalent chromium was detected in eight samples.
- A single measurement failed a screen for SDGA, which represents a 12.50 percent failure rate.

11.4 Concentrations

This section typically presents various concentration averages used to characterize pollution levels at the monitoring site for each of the site-specific pollutants of interest. However, the short sampling duration at SDGA prevents an annual average concentration for hexavalent chromium to be calculated. In order to facilitate a review of the data collected at SDGA in 2013, a few statistical calculations are provided in the sections that follow. Site-specific statistical summaries for SDGA are also provided in Appendix O. Concentration averages and statistical metrics are also presented from previous years of sampling in order to characterize concentration trends at the site. The concentration comparison analysis was not performed.

11.4.1 2013 Concentration Averages

Quarterly concentration averages were calculated for hexavalent chromium for SDGA site, as described above. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average*, which includes all measured detections and substituted zeros for non-detects for the entire year of sampling, could not be calculated as sampling at SDGA was discontinued at the end of July 2013. Quarterly average concentrations for SDGA are presented in Table 11-5, where applicable. Note that if a

pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 11-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Georgia Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
Decatur, Georgia - SDGA						
Hexavalent Chromium	8/30	0.002 ± 0.003	0.015 ± 0.016	NA	NA	NA

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

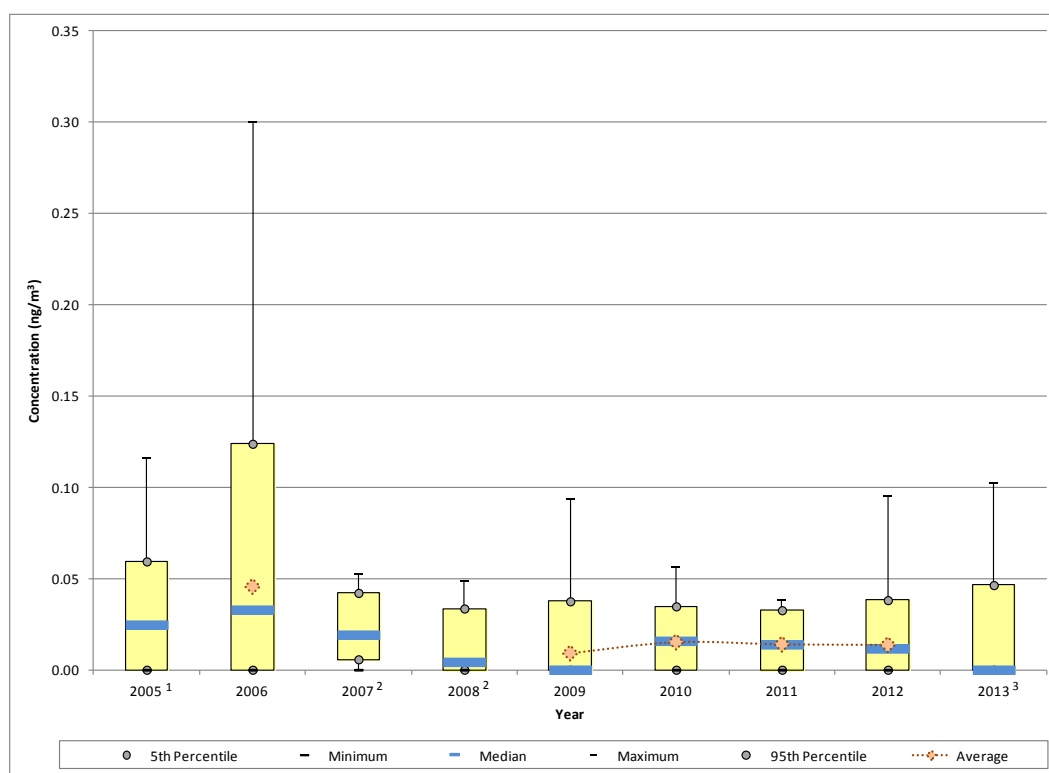
Observations for SDGA from Table 11-5 include the following:

- Hexavalent chromium was detected in roughly 27 percent of the samples collected at SDGA.
- Measured detections of hexavalent chromium range from 0.0068 ng/m³ to 0.103 ng/m³.
- There were only two measured detections during the first quarter of 2013 and both were measured in samples collected in January; thus, only non-detects were measured in February and March. For the second quarter, there were no measured detections in April, two measured detections were measured in May samples, including the maximum concentration measured on May 22, 2013, and three were collected in June samples. The final measured detection was measured in a sample collected on the final sample day, July 15, 2015.
- The relatively large number of non-detects included in the available quarterly average concentration calculations explains why the confidence interval is greater than the average itself for each quarterly average.
- Third and fourth quarter averages, as well as an annual average, could not be calculated because hexavalent chromium sampling was discontinued in July. However, statistical summaries for the entire period of sampling at SDGA are provided in Appendix O.

11.4.2 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. SDGA has sampled hexavalent chromium under the NMP since 2005. Thus, Figure 11-4 presents the 1-year statistical metrics for this pollutant for SDGA. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began (or ended) mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 11-4. Yearly Statistical Metrics for Hexavalent Chromium Concentrations Measured at SDGA



¹ A 1-year average is not presented because sampling under the NMP did not begin until late February 2005.

² 1-Year averages are not presented because there was a break in sampling between Sept 2007 and May 2008.

³ A 1-year average is not presented because sampling under the NMP was discontinued in July 2013.

Observations from Figure 11-4 for hexavalent chromium measurements collected at SDGA include the following:

- Because hexavalent chromium sampling under the NMP began at SDGA in late February 2005, a 1-year average is not presented for 2005. In addition, there was a break in sampling between September 2007 and May 2008 due to sampler issues; as a result, a 1-year average is not provided for 2007 or 2008. A 1-year average is also not presented for 2013 as sampling at SDGA was discontinued in July 2013.
- The maximum concentration was measured in 2006 (0.300 ng/m³). Five of the six concentrations greater than 0.1 ng/m³ measured at SDGA were measured in either 2005 or 2006. The sixth was measured on May 22, 2013.
- The difference between the 5th and 95th percentiles exhibits little change over the years of sampling after 2006, indicating that a majority of the measurements fall within a fairly similar range.
- The median concentration decreased significantly between 2006 and 2009, reaching a minimum of zero for 2009, which indicates that at least half of the measurements were non-detects. Since the onset of sampling in 2005, the number of non-detects has varied from 5 percent (2007) to 73 percent (2013). Note, however, that both 2007 and 2013 were partial sampling years. The median concentration increased considerably from 2009 to 2010, then changed little through 2012. This is also true for the 1-year average concentrations for 2010 through 2012. The median concentration returned to zero for 2013 even though the range of measurements is at its largest since 2006.

11.5 Additional Risk-Based Screening Evaluations

In order to characterize risk at participating monitoring sites, additional risk-based screening evaluations were conducted. Because an annual average could not be calculated for the pollutant sampled at SDGA, cancer risk and noncancer hazard approximations, as described in Section 3.4.3.3, were not calculated. The risk-based emissions assessment described in Section 3.4.3.4 was still conducted, at least in part, as the emissions can be reviewed independent of concentrations measured.

11.5.1 Risk-Based Emissions Assessment

This section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively, and is intended to help policy-makers prioritize their air monitoring activities. Table 11-6 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 11-6 also presents the 10 pollutants

with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. The emissions and toxicity-weighted emissions are shown in descending order in Table 11-6. Table 11-7 presents similar information, but is limited to those pollutants with noncancer toxicity factors. Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. A more in-depth discussion of this analysis is provided in Section 3.4.3.4.

Observations from Table 11-6 include the following:

- Benzene, ethylbenzene, and formaldehyde are the highest emitted pollutants with cancer UREs in DeKalb County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, benzene, and 1,3-butadiene.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for DeKalb County.
- Hexavalent chromium is not among the highest emitted pollutants in DeKalb County nor is it among those with the highest toxicity-weighted emissions. Hexavalent chromium ranks 28th for total emissions and 12th for its toxicity-weighted emissions.

Observations from Table 11-7 include the following:

- Toluene, hexane, and xylenes are the highest emitted pollutants with noncancer RfCs in DeKalb County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, 1,3-butadiene, and formaldehyde.
- Four of the highest emitted pollutants in DeKalb County also have the highest toxicity-weighted emissions.
- Hexavalent chromium is not among the highest emitted pollutants in DeKalb County nor is it among those with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs). Hexavalent chromium ranks 55th for total emissions and 29th for its toxicity-weighted emissions.

Table 11-6. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Georgia Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Decatur, Georgia (DeKalb County) - SDGA					
Benzene	188.80	Formaldehyde	1.54E-03		
Ethylbenzene	128.35	Benzene	1.47E-03		
Formaldehyde	118.30	1,3-Butadiene	9.04E-04		
Acetaldehyde	79.46	Naphthalene	4.67E-04		
1,3-Butadiene	30.14	Ethylbenzene	3.21E-04		
Tetrachloroethylene	19.09	POM, Group 2b	2.45E-04		
Naphthalene	13.72	POM, Group 2d	2.07E-04		
POM, Group 2b	2.78	Acetaldehyde	1.75E-04		
POM, Group 2d	2.35	POM, Group 5a	1.56E-04		
Trichloroethylene	2.32	Arsenic, PM	1.54E-04		

Table 11-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Georgia Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Decatur, Georgia (DeKalb County) - SDGA					
Toluene	834.60	Acrolein	336,255.68		
Hexane	484.49	1,3-Butadiene	15,072.00		
Xylenes	474.91	Formaldehyde	12,071.56		
Methanol	395.10	Acetaldehyde	8,828.36		
Benzene	188.80	Benzene	6,293.24		
Ethylene glycol	137.48	Xylenes	4,749.05		
Ethylbenzene	128.35	Naphthalene	4,574.95		
Formaldehyde	118.30	Lead, PM	3,306.94		
Acetaldehyde	79.46	Arsenic, PM	2,388.76		
Methyl isobutyl ketone	55.33	Trichloroethylene	1,159.47		

11.6 Summary of the 2013 Monitoring Data for SDGA

Results from several of the data treatments described in this section include the following:

- ❖ *Hexavalent chromium was the only pollutant sampled for at SDGA in 2013. Sampling was discontinued at this location in mid-July.*
- ❖ *Hexavalent chromium was detected in about one-quarter of samples collected. Concentrations of this pollutant failed only one screen for SDGA.*

12.0 Sites in Illinois

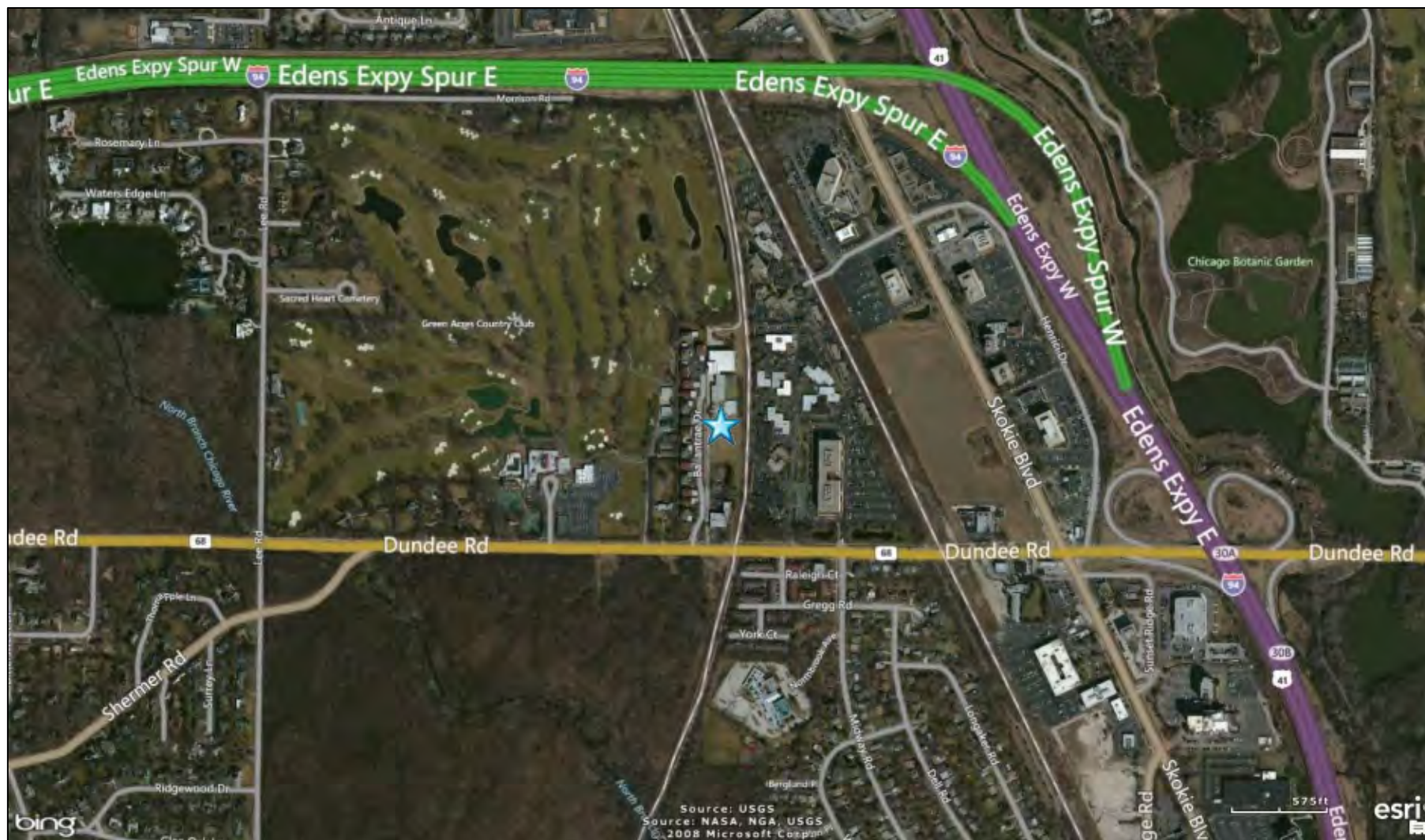
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Illinois, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

12.1 Site Characterization

This section characterizes the Illinois monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

Two monitoring sites are located in northwestern suburbs of Greater Chicago. NBIL is located in Northbrook and SPIL is located in Schiller Park. The third site (ROIL) is located in Roxana, just north of the St. Louis CBSA. Figures 12-1 and 12-2 are composite satellite images retrieved from ArcGIS Explorer showing the Chicago monitoring sites and their immediate surroundings. Figure 12-3 identifies the nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2, for NBIL and SPIL. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 12-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile boundaries are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Figures 12-4 and 12-5 present the composite satellite image and facility map for ROIL, respectively. Table 12-1 provides supplemental geographical information such as land use, location setting, and locational coordinates for each site.

Figure 12-1. Northbrook, Illinois (NBIL) Monitoring Site



12-3

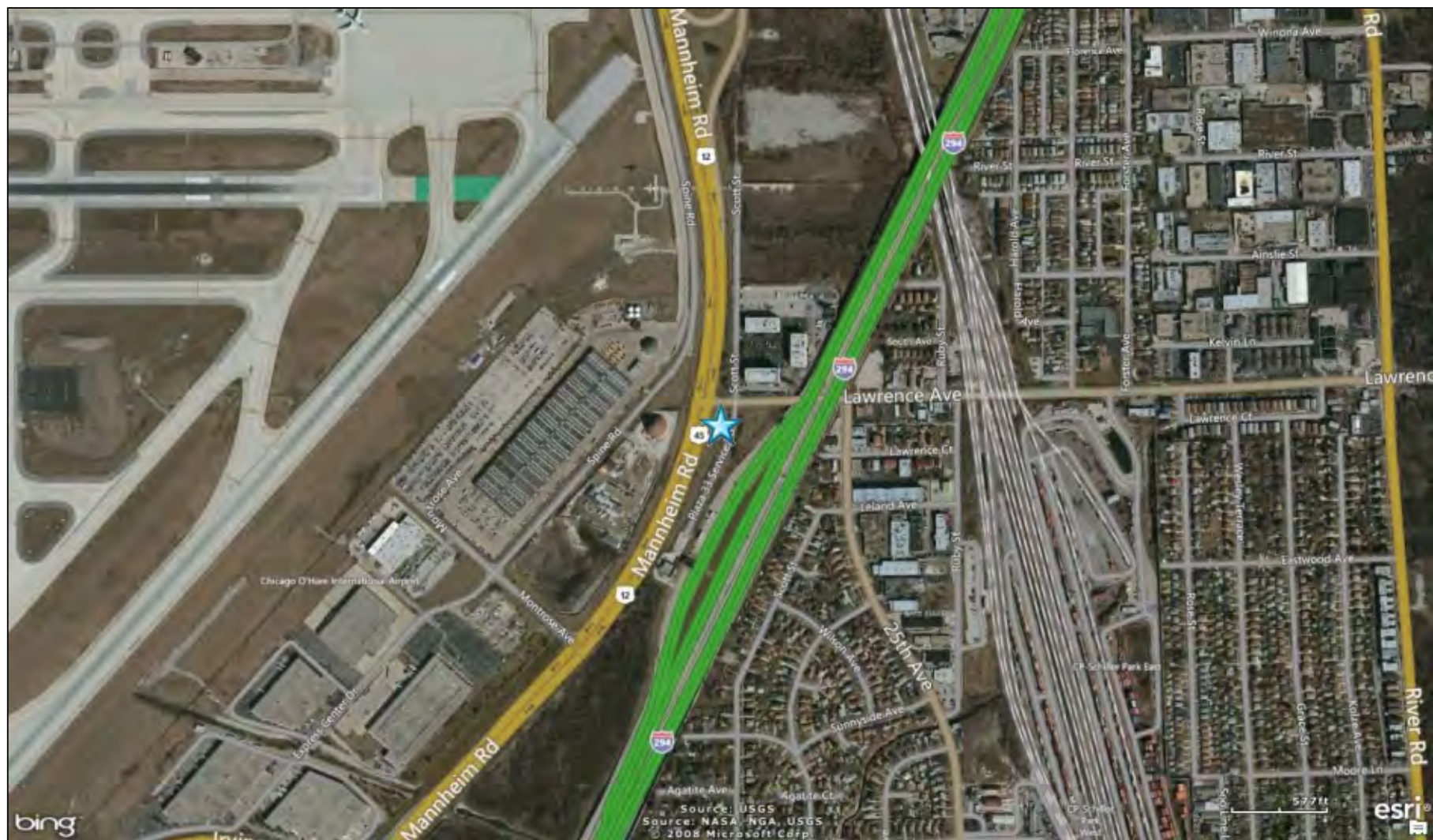
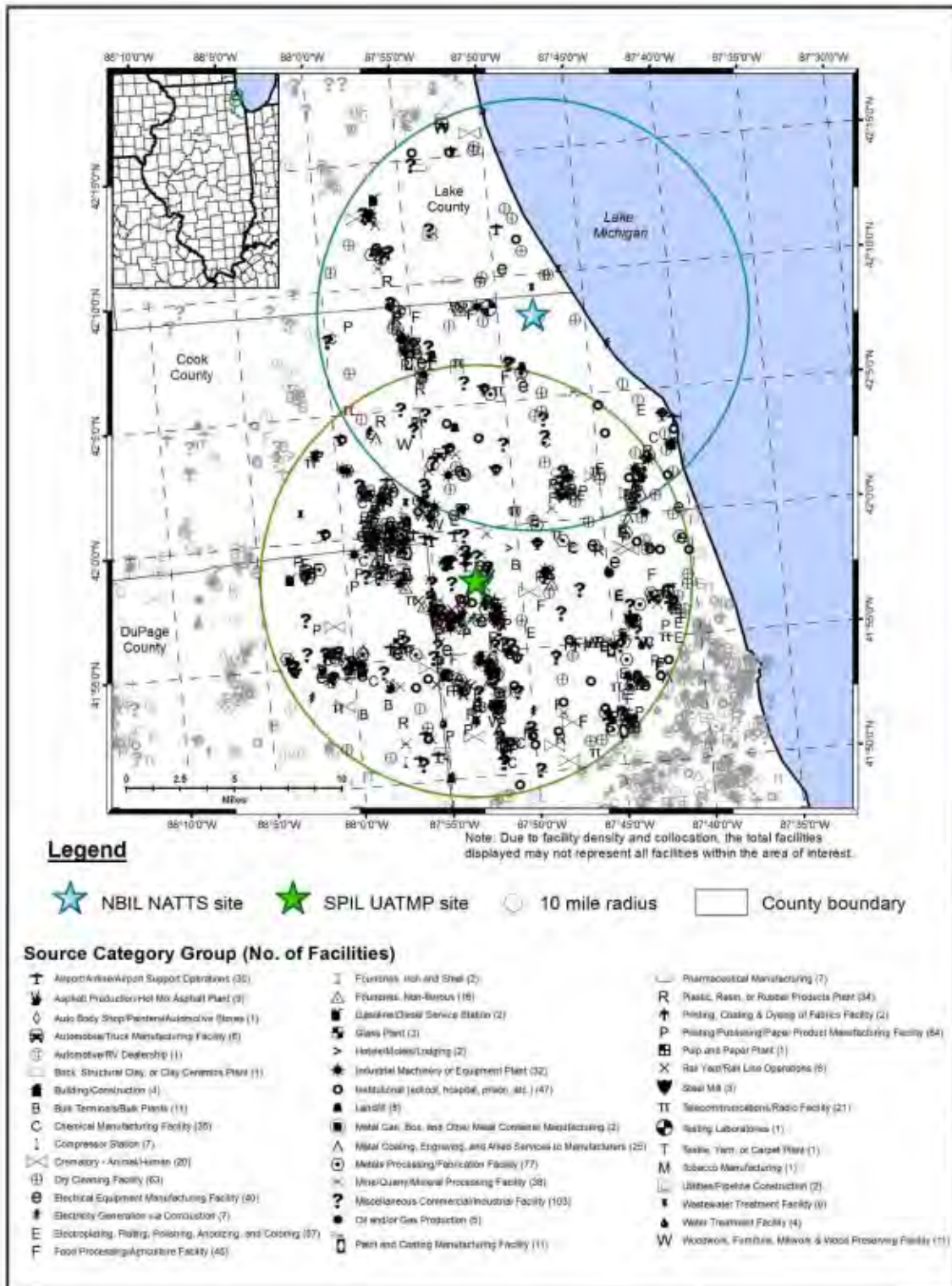


Figure 12-3. NEI Point Sources Located Within 10 Miles of NBIL and SPIL



12-5



Figure 12-5. NEI Point Sources Located Within 10 Miles of ROIL

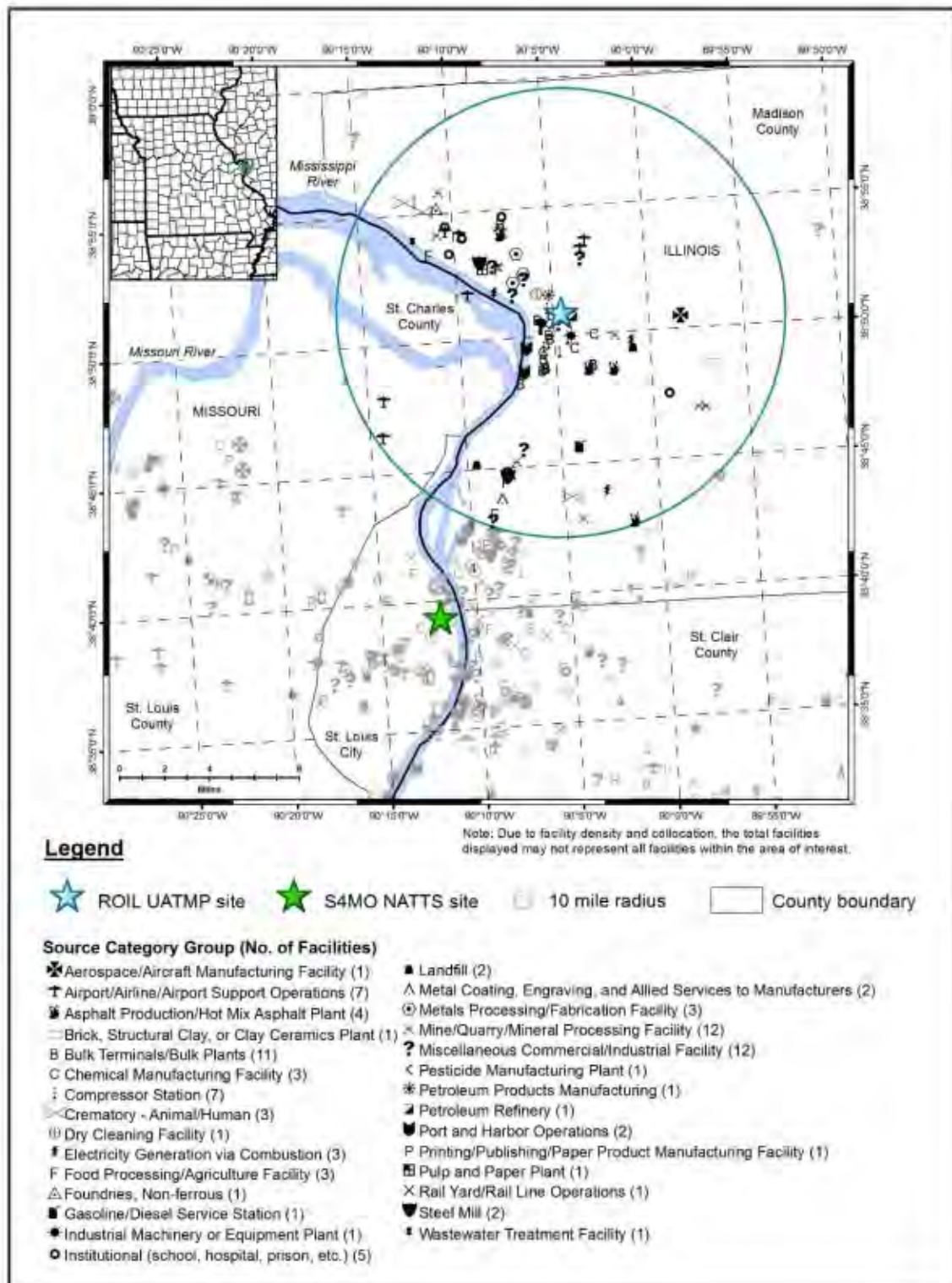


Table 12-1. Geographical Information for the Illinois Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>NBIL</i>	17-031-4201	Northbrook	Cook	Chicago-Naperville-Elgin IL-IN-WI	42.139996, -87.799227	Residential	Suburban	TSP, TSP Metals, CO, SO ₂ , NO, NO ₂ , NO _x , NO _y , O ₃ , Meteorological parameters, PM ₁₀ , PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
SPIL	17-031-3103	Schiller Park	Cook	Chicago-Naperville-Elgin IL-IN-WI	41.965193, -87.876265	Mobile	Suburban	TSP, TSP Metals, NO, NO ₂ , NO _x , O ₃ Meteorological parameters, PM _{2.5} , PM _{2.5} Speciation.
ROIL	17-119-9010	Roxana	Madison	St. Louis, MO-IL	38.848382, -90.076413	Industrial	Suburban	IMPROVE Speciation, Meteorological parameters, PM _{2.5} Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

NBIL is located on the property of the Northbrook Water Filtration Station. Figure 12-1 shows that NBIL is located off State Highway 68 (Dundee Road), near Exit 30 on I-94. A railway runs north-south in front of the water filtration station, separating the municipal buildings and nearby residential subdivision from a business complex to the east, and intersects Dundee Road just south of the monitoring site. The surrounding area is classified as suburban and residential. Commercial, residential, and forested areas surround the site, as well as a country club and golf course. The NBIL monitoring site is the Chicago NATTS site.

SPIL is located on the eastern edge of the Chicago-O'Hare International Airport, between Mannheim Road and I-294, just north of the toll plaza. The nearest runway is less than one-half mile from the site. The surrounding area is classified as suburban and mobile. Commercial and residential areas are located to the east of the airport and I-294. The rail yard located to the east of I-294 is an intermodal terminal/facility that has been closed (Podmolik, 2015).

NBIL and SPIL are located within 13 miles of each other. Each site is located within 10 miles of numerous point sources, although the quantity of emissions sources is higher near SPIL than NBIL, as shown in Figure 12-3. The source categories with the largest number of sources within 10 miles of NBIL and SPIL are printing/publishing/paper product manufacturing; metals processing/fabrication; dry cleaning; electroplating, plating, polishing, anodizing, and coloring; institutions (schools, hospitals, prisons, etc.); and food processing/agriculture. Few point sources are located within 2 miles of NBIL, with most of the sources located farther west or south. The closest source to NBIL is plotted under the symbol for the site in Figure 12-3; this source is a dry cleaning facility. Besides the airport and related operations, the closest point source to SPIL is involved in electroplating, plating, polishing, anodizing, and coloring.

The ROIL monitoring site in Roxana is located at the fence line of a petroleum refinery. Although this area is classified as industrial, a residential area is wedged between the industrial properties, as Figure 12-4 shows. Just north of the monitoring site are a junior high school and a high school, whose track and tennis courts are shown across the street from the monitoring site. North of the schools is a community park. Ambient monitoring data from this location will be used to assess near-field concentrations in the neighboring community, with emphasis on comparing and contrasting these data to the St. Louis NATTS site (S4MO), which is also

pictured in Figure 12-5. The Mississippi River, which is the border between Missouri and Illinois, is just over a mile and a half west of the ROIL monitoring site.

In addition to showing the ROIL monitoring site's location relative to the S4MO monitoring site, Figure 12-5 also shows the point sources within 10 miles of each site (although only the facilities within 10 miles of ROIL are included in the facility counts below the map). There is a large cluster of emissions sources surrounding and mostly to the south and northwest of ROIL. Many of the sources within 2 miles of ROIL are involved in or related to the petroleum industry. A petroleum refinery, multiple compressor stations, and several bulk terminals surround the site. Other nearby sources include a rail yard, an industrial machinery/equipment facility, and several chemical manufacturers.

Table 12-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Illinois monitoring sites. Table 12-2 includes both county-level population and vehicle registration information. Table 12-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 12-2 presents the county-level daily VMT for Cook County and Madison County.

Table 12-2. Population, Motor Vehicle, and Traffic Information for the Illinois Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
<i>NBIL</i>	Cook	5,240,700	2,074,419	115,700	I-94 north of Dundee Rd	87,972,644
SPIL				186,100	I-294, just south of Lawrence Ave	
ROIL	Madison	267,225	267,302	7,750	S Central Ave at Hawthorne Ave	7,911,443

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect 2014 data (IL SOS, 2014)

³AADT reflects 2012 data for SPIL and 2013 data for NBIL and ROIL (IL DOT, 2012/2013)

⁴County-level VMT reflects 2013 data (IL DOT, 2013)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 12-2 include the following:

- Cook County has the second highest county-level population (behind only Los Angeles County, California) and fourth highest county-level vehicle registration compared to other counties with NMP sites.

- Both the county-level population and vehicle registration for Madison County are an order of magnitude less than those for Cook County and rank 33rd for population and 31st for vehicle registration compared to other counties with NMP sites. Note the difference between the population and vehicle registration for these two counties. There is a nearly one-to-one ratio of vehicles to people in Madison County while the population of Cook County is more than double the number of registered vehicles.
- SPIL experiences the highest traffic volume compared to the other sites in Illinois, although both Chicago sites experience a significantly higher traffic volume than ROIL. SPIL's traffic volume is the fourth highest among all NMP sites. The traffic volume for NBIL is in the top third among NMP sites while traffic volume near ROIL is in the bottom third. Note that the traffic volumes presented for NBIL and SPIL are from interstate highways while the traffic volume for ROIL is not.
- The Cook County daily VMT is nearly 88 million miles and ranks third highest among counties with NMP sites, behind only Los Angeles County, California and Maricopa County, Arizona. The daily VMT for Madison County is an order of magnitude less than the VMT for Cook County, ranking in the middle third among VMT for counties with NMP sites.

12.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Illinois on sample days, as well as over the course of the year.

12.2.1 Climate Summary

Daily weather fluctuations are common for the Chicago area. The proximity of Chicago to Lake Michigan offers moderating effects from the continental climate of the region. In the winter, cold air masses may be moderated by their passage over the relatively warm Lake Michigan while in the summer, afternoon lake breezes can cool the city when winds from the south and southwest push temperatures upward. The lake also influences precipitation as the origin of an air mass determines the amount and type of precipitation. The largest snowfalls tend to occur when cold air masses flow southward over Lake Michigan, most of which does not freeze in winter. Wind speeds average around 10 miles per hour, but can be greater due to winds channeling between tall buildings downtown, giving the city its nickname, "The Windy City". The urban heat island effect is another climatic feature of the Chicago area, as the highly developed urban area absorbs and retains more heat than outlying areas (IL SCO, 2015; Wood, 2004).

Roxana is northeast of St. Louis and located just north of the confluence of the Mississippi and Missouri Rivers, which acts as Illinois' western border. The area has a climate that is continental in nature, with cold, dry winters; warm, somewhat wetter summers; and significant seasonal variability. Warm, moist air flowing northward from the Gulf of Mexico alternates with cold, dry air marching southward from Canada and the northern U.S., resulting in weather patterns that do not persist for very long. Precipitation tends to be higher in the summer months than the winter months and severe weather in the form of thunderstorms, flooding, and tornadoes have occurred within the region. Southerly winds prevail in the summer and fall while northwesterly winds are prevalent during the colder months of the year. (Wood, 2004; MCC, 2015).

12.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the Illinois monitoring sites (NCDC, 2013), as described in Section 3.4.2. The closest weather stations are located at Palwaukee Municipal Airport (near NBIL), O'Hare International Airport (near SPIL), and Lambert-St. Louis International Airport (near ROIL), WBANs 04838, 94846, and 13994, respectively. Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 12-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 12-3. Average Meteorological Conditions near the Illinois Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Northbrook, Illinois - NBIL									
Palwaukee Municipal Airport 04838 (42.12, -87.90)	5.6 miles	Sample Days (62)	56.5 ± 5.7	48.5 ± 5.4	38.4 ± 5.4	43.8 ± 5.0	70.2 ± 2.8	1017.9 ± 2.0	6.2 ± 0.5
	256° (WSW)	2013	57.2 ± 2.2	49.3 ± 2.1	38.7 ± 2.0	44.3 ± 1.9	69.1 ± 1.1	1017.5 ± 0.7	6.5 ± 0.3
Schiller Park, Illinois - SPIL									
O'Hare International Airport 94846 (42.00, -87.93)	3.6 miles	Sample Days (62)	57.1 ± 5.9	49.3 ± 5.5	39.4 ± 5.5	44.7 ± 5.1	70.8 ± 3.0	1017.3 ± 2.0	8.0 ± 0.6
	305° (NW)	2013	57.3 ± 2.2	49.5 ± 2.1	39.2 ± 2.0	44.7 ± 1.9	69.8 ± 1.2	1016.8 ± 0.7	8.4 ± 0.3
Roxana, Illinois - ROIL									
Lambert/ St. Louis International Airport 13994 (38.75, -90.37)	17.4 miles	Sample Days (61)	63.4 ± 5.5	55.4 ± 5.3	42.6 ± 5.4	49.1 ± 4.8	64.7 ± 3.0	1018.5 ± 2.0	7.0 ± 0.6
	248° (WSW)	2013	65.2 ± 2.1	56.5 ± 2.0	43.1 ± 2.0	49.8 ± 1.8	63.3 ± 1.1	1017.9 ± 0.7	7.3 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 12-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 12-3 is the 95 percent confidence interval for each parameter. As shown in Table 12-3, average meteorological conditions on sample days near NBIL, SPIL, and ROIL were representative of average weather conditions experienced throughout the year near these sites. The largest difference shown in Table 12-3 is for ROIL and the temperature parameters, although the difference is not significant. Note the difference in the temperature parameters between the Chicago sites and ROIL. These differences are expected, given the roughly 250 mile distance between these sites.

12.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations at Palwaukee Municipal Airport (for NBIL), O'Hare International Airport (for SPIL), and Lambert/St. Louis International Airport (for ROIL) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

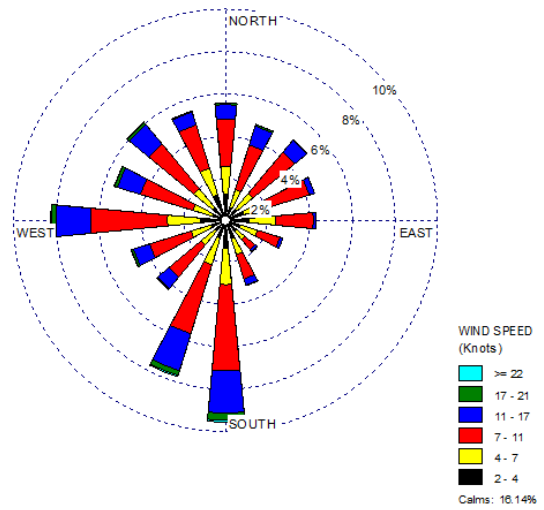
Figure 12-6 presents a map showing the distance between the weather station and NBIL, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 12-6 also presents three different wind roses for the NBIL monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 12-7 and 12-8 present the distance map and three wind roses for SPIL and ROIL, respectively.

Figure 12-6. Wind Roses for the Palwaukee Municipal Airport Weather Station near NBIL

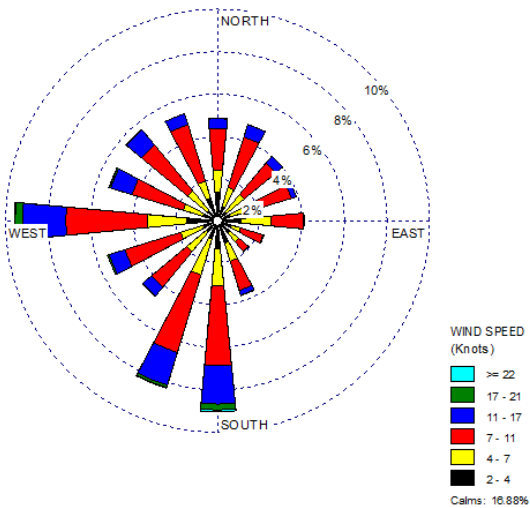
Location of NBIL and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

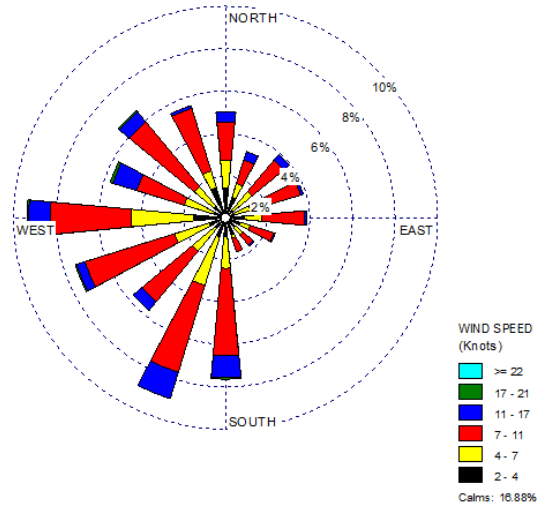


Figure 12-7. Wind Roses for the O’Hare International Airport Weather Station near SPIL

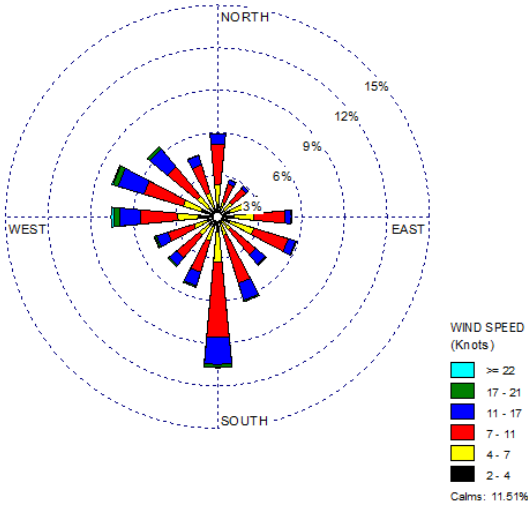


Figure 12-8. Wind Roses for the Lambert/St. Louis International Airport Weather Station near ROIL

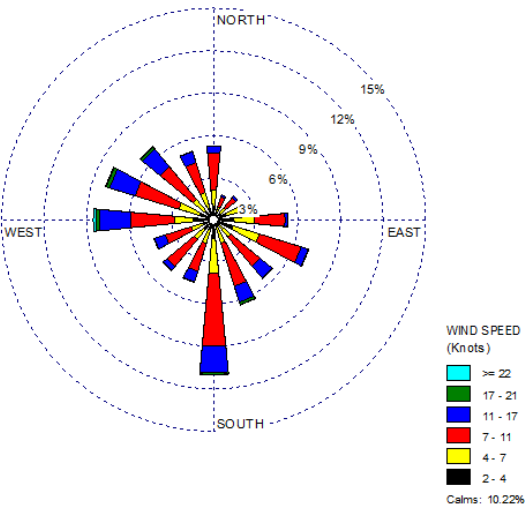
Location of ROIL and Weather Station



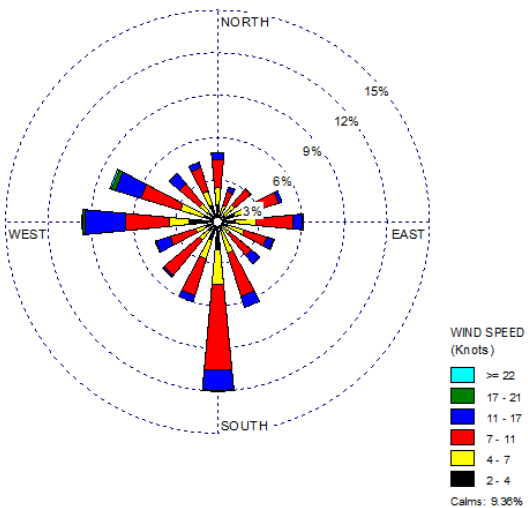
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 12-6 for NBIL include the following:

- The Palwaukee Municipal Airport weather station is located 5.6 miles west-southwest of NBIL, and about four times as far from Lake Michigan as NBIL.
- The historical wind rose shows that winds from a variety of directions were observed near NBIL. Winds from the south, south-southwest, and west together account for one-quarter of wind observations while winds with a northerly component each account for 5 percent to 6 percent of observations. Winds from the east-southeast to south-southeast were observed the least often. Calm winds (those less than or equal to 2 knots) were observed for approximately 16 percent of the hourly measurements.
- The 2013 wind rose exhibits similar patterns in wind speed and direction as the historical wind rose.
- The sample day wind patterns resemble the full-year wind patterns in that the majority of wind observations are associated with a direction on the left-hand side of the wind rose. However, the percentages are more variable. For instance, fewer southerly winds were observed on sample days while a greater percentage of south-southwesterly to west-southwesterly winds were observed. Also, winds appear lighter on sample days; winds speeds greater than 11 knots account for fewer observations on sample days than throughout the year. However, the calm rate is the same for both wind roses.

Observations from Figure 12-7 for SPIL include the following:

- The O'Hare International Airport weather station is located 3.6 miles northwest of SPIL. Most of the airport property lies between the weather station and the monitoring site.
- The historical wind rose for SPIL shows that winds from a variety of directions were observed near this site, although winds from the south to southwest to west account for the highest percentage of observations (nearly 40 percent). Winds from the southeast quadrant were observed the least. Calm winds were observed for less than 8 percent of the hourly measurements.
- The 2013 wind rose exhibits similar patterns in wind speed and direction as the historical wind rose, although winds from the west accounted for a higher percentage of the wind observations. The strongest winds were from the southwest quadrant and west.
- The sample day wind patterns resemble those of the full-year wind rose, with the winds from the south to southwest to west accounting for nearly half of the wind observations. Wind speeds appear lower on sample days. A review of the wind data shows that only one of the windiest days in 2013, based on average scalar wind speed, was a sample day at SPIL.

Observations from Figure 12-8 for ROIL include the following:

- The Lambert/St. Louis International Airport weather station is located 17.4 miles west-southwest of ROIL. The airport lies on the northwest side St. Louis and south of the Missouri River.
- The historical wind rose for ROIL shows that winds from a variety of directions were observed, with winds from the south observed the most. Winds from the west to northwest were also common while winds from the northeast quadrant were observed the least. Calm winds were observed for less than 12 percent of the hourly measurements.
- The 2013 wind rose exhibits similar patterns in wind speed and direction as the historical wind rose, although the calm rate is slightly less.
- The predominant wind direction on the sample day wind rose is still south, but the similarities in the wind patterns are fewer. Winds from the east-northeast and east account for a greater percentage of winds on sample days while winds from the east-southeast and southeast account for fewer wind observations. There were also fewer northwesterly wind observations on sample days. The percentage of calm winds is also less than 10 percent.

12.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Illinois monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 12-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 12-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. VOCs, carbonyl compounds, SNMOCs, metals (PM₁₀), PAHs, and hexavalent chromium were sampled for at NBIL, while only VOCs and carbonyl compounds were sampled for at SPIL and ROIL.

Table 12-4. Risk-Based Screening Results for the Illinois Monitoring Sites

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Northbrook, Illinois - NBIL						
Acetaldehyde	0.45	62	62	100.00	12.16	12.16
Formaldehyde	0.077	62	62	100.00	12.16	24.31
Benzene	0.13	61	61	100.00	11.96	36.27
Carbon Tetrachloride	0.17	61	61	100.00	11.96	48.24
1,2-Dichloroethane	0.038	53	53	100.00	10.39	58.63
Arsenic (PM ₁₀)	0.00023	47	59	79.66	9.22	67.84
Naphthalene	0.029	45	58	77.59	8.82	76.67
1,3-Butadiene	0.03	33	38	86.84	6.47	83.14
Acenaphthene	0.011	29	58	50.00	5.69	88.82
Fluorene	0.011	27	57	47.37	5.29	94.12
Fluoranthene	0.011	13	58	22.41	2.55	96.67
Ethylbenzene	0.4	4	61	6.56	0.78	97.45
Chloroform	9.8	3	61	4.92	0.59	98.04
<i>p</i> -Dichlorobenzene	0.091	2	8	25.00	0.39	98.43
Dichloromethane	60	2	61	3.28	0.39	98.82
Trichloroethylene	0.2	2	14	14.29	0.39	99.22
Bromoform	0.91	1	6	16.67	0.20	99.41
Hexachloro-1,3-butadiene	0.045	1	1	100.00	0.20	99.61
Hexavalent Chromium	0.000083	1	13	7.69	0.20	99.80
Tetrachloroethylene	3.8	1	48	2.08	0.20	100.00
Total		510	900	56.67		
Schiller Park, Illinois - SPIL						
Acetaldehyde	0.45	60	61	98.36	15.08	15.08
Benzene	0.13	60	60	100.00	15.08	30.15
Carbon Tetrachloride	0.17	60	60	100.00	15.08	45.23
Formaldehyde	0.077	60	61	98.36	15.08	60.30
1,3-Butadiene	0.03	59	59	100.00	14.82	75.13
1,2-Dichloroethane	0.038	57	57	100.00	14.32	89.45
Trichloroethylene	0.2	18	44	40.91	4.52	93.97
Hexachloro-1,3-butadiene	0.045	9	10	90.00	2.26	96.23
<i>p</i> -Dichlorobenzene	0.091	5	28	17.86	1.26	97.49
Propionaldehyde	0.8	5	60	8.33	1.26	98.74
Ethylbenzene	0.4	4	60	6.67	1.01	99.75
1,2-Dibromoethane	0.0017	1	1	100.00	0.25	100.00
Total		398	561	70.94		

Table 12-4. Risk-Based Screening Results for the Illinois Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Roxana, Illinois - ROIL						
Acetaldehyde	0.45	61	61	100.00	16.40	16.40
Formaldehyde	0.077	61	61	100.00	16.40	32.80
Benzene	0.13	60	60	100.00	16.13	48.92
Carbon Tetrachloride	0.17	60	60	100.00	16.13	65.05
1,3-Butadiene	0.03	51	54	94.44	13.71	78.76
1,2-Dichloroethane	0.038	45	45	100.00	12.10	90.86
Hexachloro-1,3-butadiene	0.045	15	15	100.00	4.03	94.89
Ethylbenzene	0.4	13	60	21.67	3.49	98.39
Propionaldehyde	0.8	3	61	4.92	0.81	99.19
<i>p</i> -Dichlorobenzene	0.091	2	28	7.14	0.54	99.73
1,2-Dibromoethane	0.0017	1	1	100.00	0.27	100.00
Total		372	506	73.52		

Observations from Table 12-4 include the following:

- The number of pollutants failing screens for NBIL is higher than the other two monitoring sites; this is expected given the difference in pollutants measured at each site.
- Twenty pollutants failed at least one screen for NBIL; 57 percent of concentrations for these 20 pollutants were greater than their associated risk screening value (or failed screens).
- Eleven pollutants contributed to 95 percent of failed screens for NBIL and therefore were identified as pollutants of interest for this site. These 11 include two carbonyl compounds, four VOCs, one PM₁₀ metal, and four PAHs.
- NBIL failed the third highest number of screens (510) among all NMP sites, as shown in Table 4-8 of Section 4.2. However, the failure rate for NBIL, when incorporating all pollutants with screening values, is relatively low, at 20 percent. This is due primarily to the relatively high number of pollutants sampled for at this site. NBIL is one of only two NMP sites sampling for all six pollutant groups. Recall from Section 3.2 that if a pollutant was measured by both the TO-15 and SNMOC methods at the same site, the TO-15 results were used for the risk-based screening process. As NBIL sampled both VOCs (TO-15) and SNMOCs, the TO-15 results were used for the 12 pollutants these methods have in common.
- Twelve pollutants failed screens for SPIL; approximately 71 percent of concentrations for these 12 pollutants were greater than their associated risk screening value (or failed screens).

- Eight pollutants contributed to 95 percent of failed screens for SPIL and therefore were identified as pollutants of interest for this site. These eight include two carbonyl compounds and six VOCs.
- Eleven pollutants failed screens for ROIL; approximately 74 percent of concentrations for these 11 pollutants were greater than their associated risk screening value (or failed screens).
- Eight pollutants contributed to 95 percent of failed screens for ROIL and therefore were identified as pollutants of interest for this site. These eight include two carbonyl compounds and six VOCs.
- The Illinois monitoring sites have six pollutants of interest in common: two carbonyl compounds (acetaldehyde and formaldehyde) and four VOCs (benzene, 1,3-butadiene, carbon tetrachloride, and 1,2-dichloroethane). Of these, benzene, carbon tetrachloride, and 1,2-dichloroethane failed 100 percent of screens for each site.

12.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Illinois monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at NBIL, SPIL, and ROIL are provided in Appendices J through O.

12.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Illinois site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given

calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Illinois monitoring sites are presented in Table 12-5, where applicable. Note that concentrations of the PAHs and metals for NBIL are presented in ng/m³ for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 12-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Illinois Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
Northbrook, Illinois - NBIL						
Acetaldehyde	62/62	1.75 ± 0.35	2.10 ± 0.49	2.61 ± 0.71	2.93 ± 0.76	2.37 ± 0.31
Benzene	61/61	0.60 ± 0.07	0.44 ± 0.08	0.42 ± 0.09	0.43 ± 0.10	0.47 ± 0.05
1,3-Butadiene	38/61	0.03 ± 0.02	0.03 ± 0.01	0.02 ± 0.01	0.04 ± 0.02	0.03 ± 0.01
Carbon Tetrachloride	61/61	0.58 ± 0.04	0.62 ± 0.02	0.63 ± 0.02	0.57 ± 0.05	0.60 ± 0.02
1,2-Dichloroethane	53/61	0.07 ± 0.01	0.08 ± 0.01	0.04 ± 0.02	0.06 ± 0.01	0.06 ± 0.01
Formaldehyde	62/62	1.85 ± 0.25	2.79 ± 0.58	1.95 ± 0.62	1.39 ± 0.34	1.98 ± 0.26
Acenaphthene ^a	58/58	9.41 ± 7.75	49.98 ± 18.65	39.81 ± 17.66	1.91 ± 0.84	25.12 ± 8.19
Arsenic (PM ₁₀) ^a	59/59	0.34 ± 0.09	0.77 ± 0.25	0.81 ± 0.27	0.57 ± 0.23	0.62 ± 0.11
Fluoranthene ^a	58/58	1.59 ± 0.68	12.12 ± 4.85	14.67 ± 6.62	1.44 ± 0.53	7.47 ± 2.52
Fluorene ^a	57/58	6.08 ± 4.36	38.83 ± 15.04	30.39 ± 12.39	2.10 ± 0.87	19.24 ± 6.19
Naphthalene ^a	58/58	97.57 ± 68.12	304.90 ± 119.66	194.17 ± 68.05	33.16 ± 6.41	155.94 ± 44.27

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m³ for ease of viewing.

Table 12-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Illinois Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Schiller Park, Illinois - SPIL						
Acetaldehyde	61/61	4.59 ± 1.69	1.35 ± 0.33	1.35 ± 0.22	2.20 ± 0.74	2.37 ± 0.55
Benzene	60/60	0.95 ± 0.26	0.74 ± 0.14	0.67 ± 0.09	0.61 ± 0.07	0.74 ± 0.08
1,3-Butadiene	59/60	0.16 ± 0.07	0.11 ± 0.03	0.11 ± 0.02	0.13 ± 0.02	0.13 ± 0.02
Carbon Tetrachloride	60/60	0.61 ± 0.03	0.70 ± 0.04	0.67 ± 0.03	0.59 ± 0.05	0.64 ± 0.02
1,2-Dichloroethane	57/60	0.08 ± 0.02	0.10 ± 0.01	0.07 ± 0.01	0.07 ± 0.02	0.08 ± 0.01
Formaldehyde	61/61	5.18 ± 1.39	2.31 ± 0.55	3.28 ± 0.64	2.51 ± 0.52	3.31 ± 0.49
Hexachloro-1,3-butadiene	10/60	<0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.03 ± 0.02	0.01 ± 0.01
Trichloroethylene	44/60	0.32 ± 0.44	0.30 ± 0.20	0.28 ± 0.25	0.14 ± 0.12	0.26 ± 0.13
Roxana, Illinois - ROIL						
Acetaldehyde	61/61	1.14 ± 0.17	2.02 ± 0.48	2.60 ± 0.51	1.61 ± 0.21	1.84 ± 0.22
Benzene	60/60	1.05 ± 0.17	0.86 ± 0.17	1.05 ± 0.27	0.90 ± 0.27	0.97 ± 0.11
1,3-Butadiene	54/60	0.05 ± 0.02	0.05 ± 0.02	0.06 ± 0.01	0.07 ± 0.02	0.06 ± 0.01
Carbon Tetrachloride	60/60	0.62 ± 0.05	0.70 ± 0.06	0.67 ± 0.03	0.64 ± 0.02	0.66 ± 0.02
1,2-Dichloroethane	45/60	0.07 ± 0.03	0.10 ± 0.03	0.04 ± 0.02	0.08 ± 0.02	0.07 ± 0.01
Ethylbenzene	60/60	0.27 ± 0.10	0.32 ± 0.09	0.32 ± 0.07	0.31 ± 0.11	0.31 ± 0.04
Formaldehyde	61/61	1.74 ± 0.24	3.74 ± 1.30	5.40 ± 1.27	1.95 ± 0.27	3.19 ± 0.57
Hexachloro-1,3-butadiene	15/60	<0.01 ± 0.01	0.03 ± 0.02	0.01 ± 0.01	0.04 ± 0.03	0.02 ± 0.01

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for NBIL from Table 12-5 include the following:

- The pollutants with the highest annual average concentrations are acetaldehyde ($2.37 \pm 0.31 \mu\text{g}/\text{m}^3$) and formaldehyde ($1.98 \pm 0.26 \mu\text{g}/\text{m}^3$). The annual average concentrations for the remaining pollutants of interest are less than $1 \mu\text{g}/\text{m}^3$.
- The third and fourth quarter average acetaldehyde concentrations are higher than the first and second quarter averages and have relatively large confidence intervals associated with them. A review of the data shows that acetaldehyde concentrations measured at NBIL range from $0.86 \mu\text{g}/\text{m}^3$ to $6.10 \mu\text{g}/\text{m}^3$. The three highest

acetaldehyde concentrations measured at NBIL were measured during the fourth quarter of 2013 and that all but one of the nine acetaldehyde concentrations greater than 4 $\mu\text{g}/\text{m}^3$ were measured between August and December.

- While acetaldehyde concentrations were highest at NBIL during the fourth quarter, formaldehyde concentrations were at their lowest. A review of the data shows that formaldehyde concentrations measured at NBIL range from 0.44 $\mu\text{g}/\text{m}^3$ to 5.09 $\mu\text{g}/\text{m}^3$. The 10 concentrations greater than 3 $\mu\text{g}/\text{m}^3$ were all measured between April and September, with seven of them measured between the end of May and mid-July. Conversely, the 10 concentrations less than 1 $\mu\text{g}/\text{m}^3$ were all measured between August and November.
- Of the VOCs, carbon tetrachloride and benzene have the highest annual average concentrations for NBIL. Quarterly average concentrations of carbon tetrachloride are fairly consistent. This is also true for benzene with the exception of the first quarter as the first quarter average is slightly higher than the other quarterly averages. Of the 23 benzene concentrations greater than 0.5 $\mu\text{g}/\text{m}^3$, 11 were measured during the first quarter, with four each measured during the remaining calendar quarters.
- Arsenic concentrations measured at NBIL range from 0.057 ng/m^3 to 2.07 ng/m^3 . Concentrations greater than 1 ng/m^3 were not measured during the first quarter of 2013 while at least two were measured during each of the remaining calendar quarters.
- Of the PAHs, naphthalene has the highest annual average concentration. Concentrations of each of the PAH pollutants of interest were significantly higher during the warmer months of the year and exhibit a relatively large amount of variability, based on the confidence intervals. Concentrations of naphthalene measured at NBIL range from 2.87 ng/m^3 to 748 ng/m^3 . The maximum concentration measured at NBIL is the highest naphthalene concentration measured across the program. This explains the large confidence interval associated with NBIL's second quarter naphthalene concentration, when concentrations span an order of magnitude. Five of the seven highest naphthalene concentrations measured across the program (those greater than 400 ng/m^3) were measured at NBIL and these were measured between April and July.
- Some of the highest concentrations of acenaphthene, fluorene, and fluoranthene measured across the program were also measured at NBIL. Concentrations of acenaphthene measured at NBIL range from 0.145 ng/m^3 to 123 ng/m^3 , accounting for eight of the nine highest acenaphthene measurements across the program and the only two greater than 100 ng/m^3 . Concentrations of fluorene measured at NBIL range from 0.357 ng/m^3 to 99.1 ng/m^3 , accounting for 10 of the 12 highest fluorene measurements across the program. Concentrations of fluoranthene range from 0.163 ng/m^3 to 43.7 ng/m^3 , with the second, third, and fourth highest fluoranthene concentrations across the program measured at NBIL.
- Many of the higher PAH concentrations were measured on the same days. The highest naphthalene and fluorene concentrations were measured at NBIL on May 16,

2013, along with the second highest acenaphthene and third highest fluoranthene concentrations. The highest acenaphthene concentration was measured at NBIL on July 15, 2013, along with the second highest fluorene and fluoranthene concentrations and the fourth highest naphthalene concentration.

Observations for SPIL from Table 12-5 include the following:

- The pollutants with the highest annual average concentrations are formaldehyde ($3.31 \pm 0.49 \mu\text{g}/\text{m}^3$) and acetaldehyde ($2.37 \pm 0.55 \mu\text{g}/\text{m}^3$). These are the only pollutants with annual average concentrations greater than $1 \mu\text{g}/\text{m}^3$. Of the VOCs, benzene ($0.74 \pm 0.08 \mu\text{g}/\text{m}^3$) and carbon tetrachloride ($0.64 \pm 0.02 \mu\text{g}/\text{m}^3$) have the highest annual average concentrations for SPIL.
- Several of the pollutants of interest for SPIL were highest during the first quarter of 2013, in particular acetaldehyde and formaldehyde. Concentrations of acetaldehyde measured at SPIL span three orders of magnitude, ranging from $0.0108 \mu\text{g}/\text{m}^3$ to $14.2 \mu\text{g}/\text{m}^3$. The maximum acetaldehyde concentration measured at SPIL is the highest acetaldehyde concentration measured across the program. The second highest acetaldehyde concentration measured at SPIL ($7.17 \mu\text{g}/\text{m}^3$) is roughly half as high but is still one of the 10 highest acetaldehyde concentrations measured across the program. Both of these measurements were from samples collected in February 2013. Of the 16 acetaldehyde concentrations greater than $3 \mu\text{g}/\text{m}^3$ measured at SPIL, 12 were measured in January, February, and March, with the other four in November and December. Concentrations of formaldehyde measured at SPIL also span three orders of magnitude, ranging from $0.0148 \mu\text{g}/\text{m}^3$ to $10.5 \mu\text{g}/\text{m}^3$. Five of the seven highest formaldehyde concentrations measured at SPIL were measured in January 2013, with one each in February and March.
- Benzene and 1,3-butadiene concentrations also appear higher during the first quarter of 2013, although the difference among the quarterly averages for these pollutants is smaller. For benzene, four of the five benzene concentrations greater than $1 \mu\text{g}/\text{m}^3$ were measured during the first quarter (with the fifth measured on the first sample day of the second quarter). For 1,3-butadiene, the three highest concentrations were measured in January and March.
- The first quarter average concentration of trichloroethylene has a confidence interval larger than the average itself. In addition, all of the quarterly average concentrations shown in Table 12-5 have relatively large confidence intervals associated with them. A review of the data shows that trichloroethylene was detected in roughly 73 percent of the samples collected, with measured detections ranging from $0.0404 \mu\text{g}/\text{m}^3$ to $3.21 \mu\text{g}/\text{m}^3$. The five highest trichloroethylene concentrations measured across the program were all measured at SPIL; further, 15 of the 18 highest trichloroethylene concentrations (those greater than $0.30 \mu\text{g}/\text{m}^3$) were measured at SPIL. SPIL is the only NMP site for which trichloroethylene is a pollutant of interest. Similar observations were also made in the 2011 and 2012 NMP reports.

- Hexachloro-1,3-butadiene was detected in less than 20 percent of the samples collected at SPIL. Six of the 10 measured detections were measured during the fourth quarter, with one each during the first and second quarters, and two in the third quarter.

Observations for ROIL from Table 12-5 include the following:

- The pollutants with the highest annual average concentrations are formaldehyde ($3.19 \pm 0.57 \mu\text{g}/\text{m}^3$) and acetaldehyde ($1.84 \pm 0.22 \mu\text{g}/\text{m}^3$). These are the only pollutants with annual average concentrations greater than $1 \mu\text{g}/\text{m}^3$. Of the VOCs, benzene ($0.97 \pm 0.11 \mu\text{g}/\text{m}^3$) and carbon tetrachloride ($0.66 \pm 0.02 \mu\text{g}/\text{m}^3$) have the highest annual average concentrations for ROIL. ROIL's annual average concentration of benzene is higher than the annual average concentrations for the Chicago sites.
- The second and third quarter average concentrations for formaldehyde are significantly higher than the first and fourth quarter averages. A review of the data shows that formaldehyde concentrations measured at ROIL range from $0.874 \mu\text{g}/\text{m}^3$ to $10.7 \mu\text{g}/\text{m}^3$. ROIL is one of only six NMP sites at which formaldehyde concentrations greater than $10 \mu\text{g}/\text{m}^3$ were measured; two were measured at ROIL (and a third was measured at SPIL). The 20 highest formaldehyde measurements collected at ROIL (those greater than $3 \mu\text{g}/\text{m}^3$) were all measured between April and September. Although the minimum formaldehyde concentration was measured in May, most of the lower formaldehyde concentrations were measured during the first and fourth quarters of 2013. Of the 25 formaldehyde measurements less than $2 \mu\text{g}/\text{m}^3$, 12 were measured during the first quarter and 10 were measured during the fourth quarter of 2013.
- A similar observation can be made for acetaldehyde, in that the second and third quarter average concentrations are higher than the remaining quarterly averages, although the difference is considerably less. Of the 19 highest acetaldehyde concentrations measured at ROIL (those greater than $2 \mu\text{g}/\text{m}^3$), 17 were measured between April and September. Conversely, of the eight concentrations of acetaldehyde less than $1 \mu\text{g}/\text{m}^3$, six were measured between January and March.
- Ethylbenzene is the only pollutant of interest for ROIL that is not a pollutant of interest for at least one of the Chicago sites. Ethylbenzene concentrations measured at ROIL range from $0.091 \mu\text{g}/\text{m}^3$ to $0.857 \mu\text{g}/\text{m}^3$, with a median concentration of $0.27 \mu\text{g}/\text{m}^3$; the quarterly average concentrations of ethylbenzene shown in Table 12-5 are consistent from quarter to quarter. This is true for most of the VOCs listed.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for NBIL, SPIL, and ROIL from those tables include the following:

- The Illinois monitoring sites appear in Tables 4-9 through 4-12 a total of 10 times, with NBIL appearing five times, SPIL appearing three times, and ROIL appearing twice.
- Table 4-9 for VOCs shows that SPIL ranks ninth for its annual average concentration of 1,3-butadiene while ROIL ranks seventh for its annual average concentration of hexachloro-1,3-butadiene. NBIL does not appear in Table 4-9.
- SPIL and NBIL both appear in Table 4-10, ranking sixth and seventh, respectively, for their annual average concentrations of acetaldehyde, which were similar in magnitude. SPIL and ROIL both appear in Table 4-10, ranking seventh and tenth, respectively, for their annual average concentrations of formaldehyde.
- NBIL ranks first for its annual average concentrations of acenaphthene and naphthalene among NMP sites sampling PAHs, as shown in Table 4-11. In addition to having the highest annual averages, NBIL's confidence intervals are also the largest shown, a reflection of the variability within the measurements.
- As shown in Table 4-12, NBIL's annual average concentration of arsenic ranks eighth among NMP sites sampling PM₁₀ metals. Although not a pollutant of interest for NBIL, this site's annual average concentration of nickel ranks ninth highest among NMP sites sampling PM₁₀ metals.

12.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 12-4 for NBIL, SPIL, and ROIL. Figures 12-9 through 12-22 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 12-9. Program vs. Site-Specific Average Acenaphthene Concentration

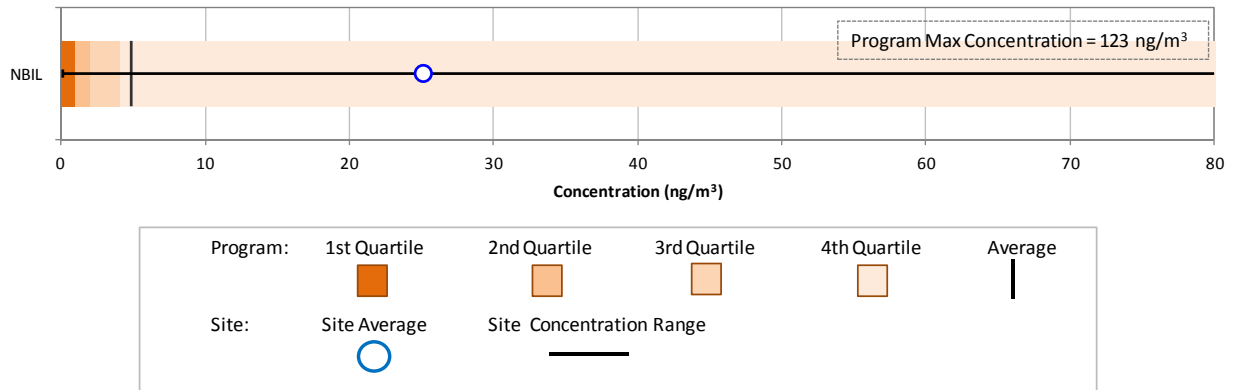


Figure 12-10. Program vs. Site-Specific Average Acetaldehyde Concentrations

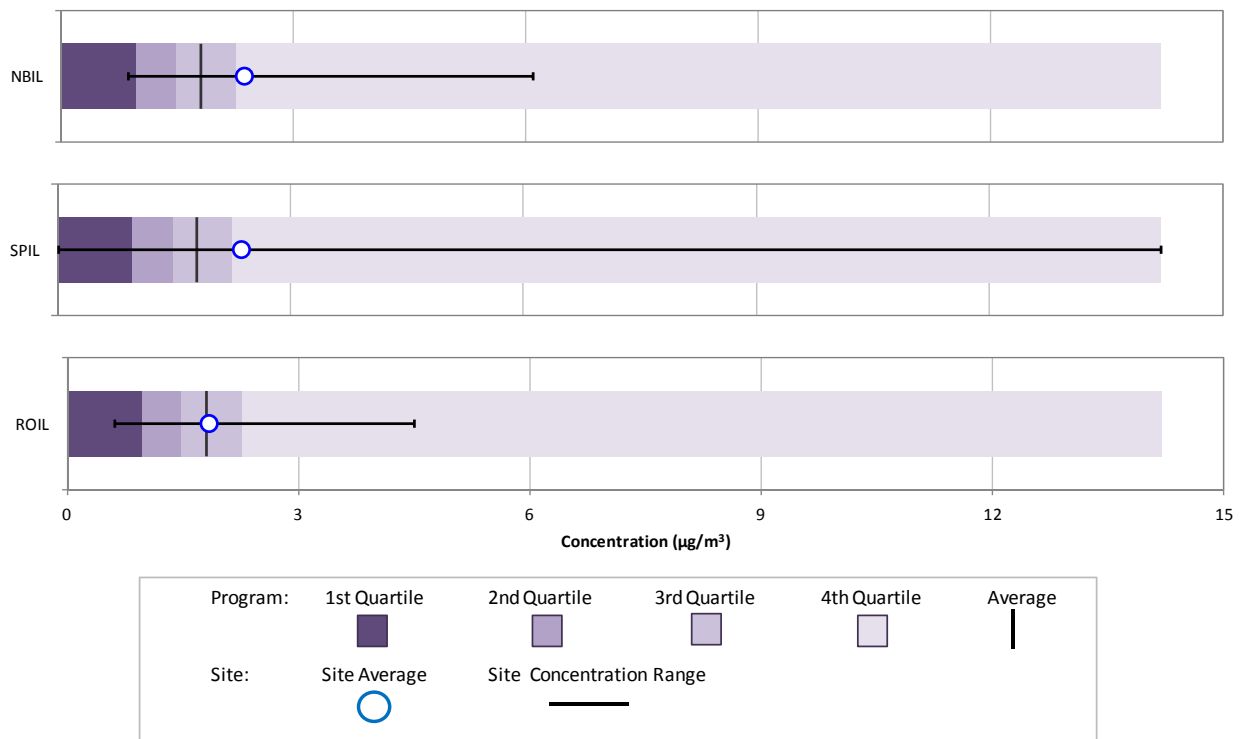


Figure 12-11. Program vs. Site-Specific Average Arsenic (PM₁₀) Concentration

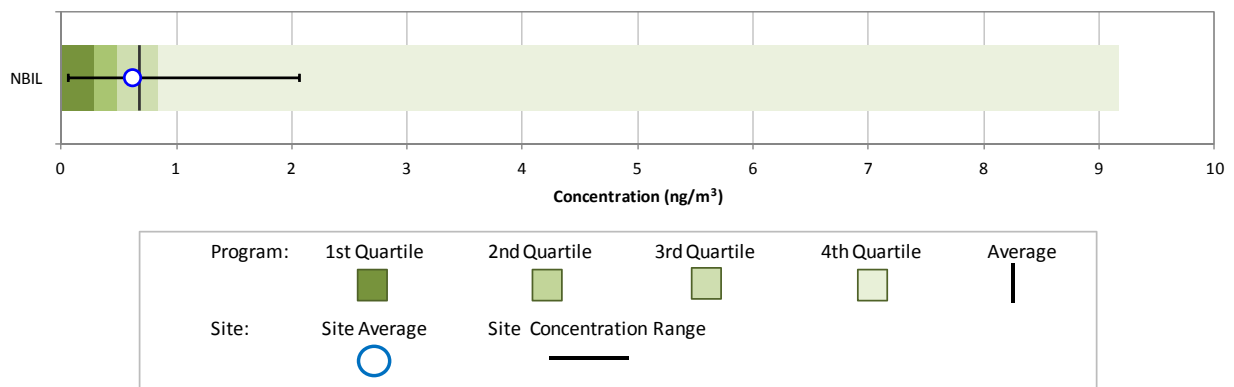


Figure 12-12. Program vs. Site-Specific Average Benzene Concentrations

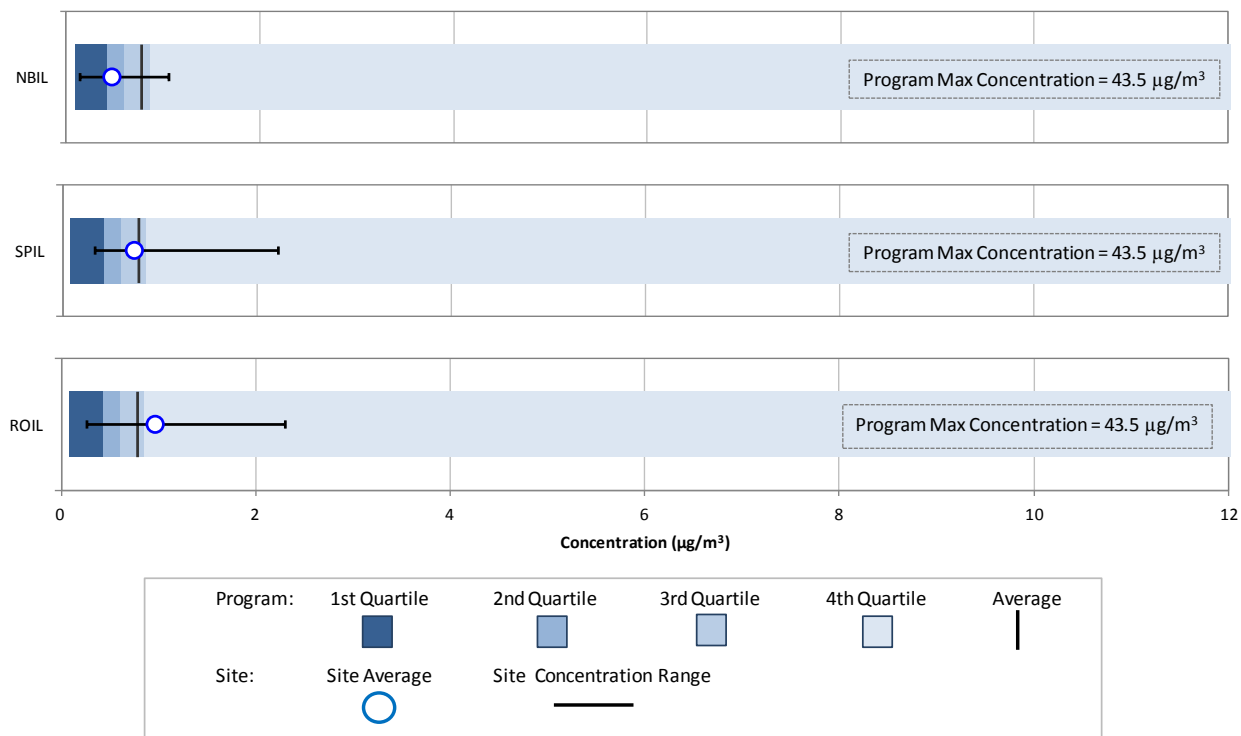


Figure 12-13. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

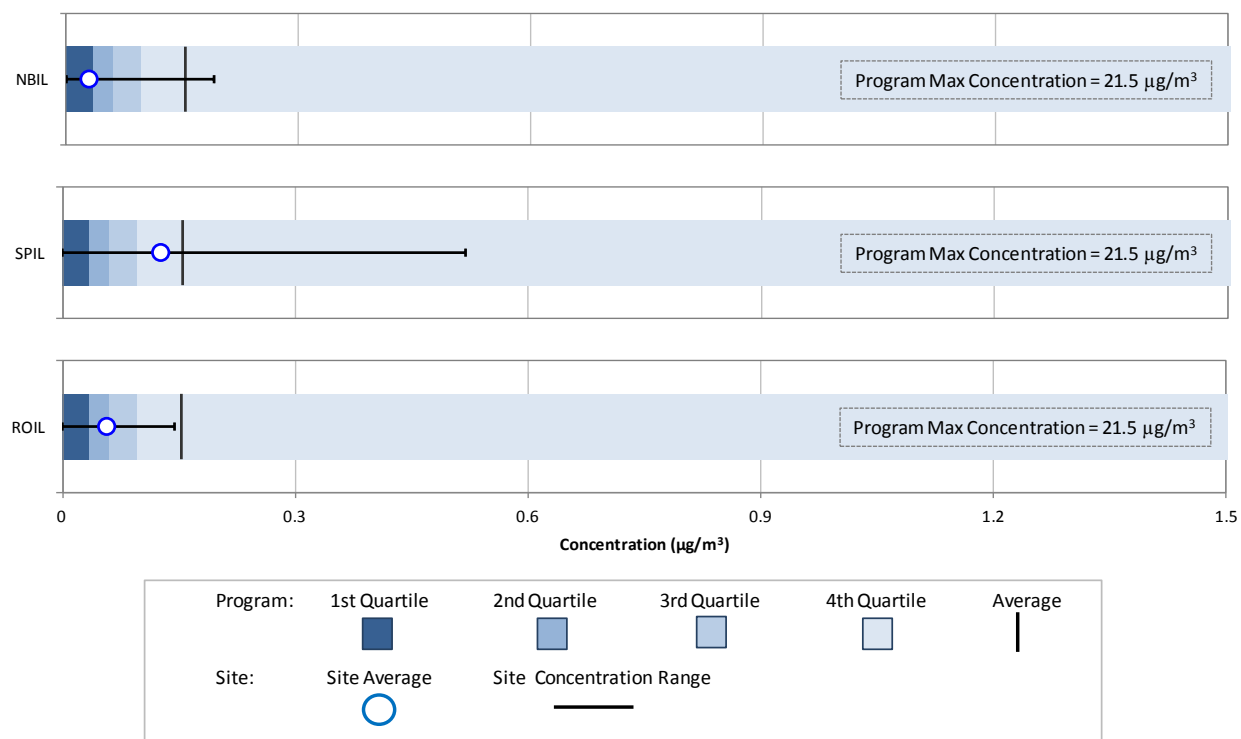


Figure 12-14. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations

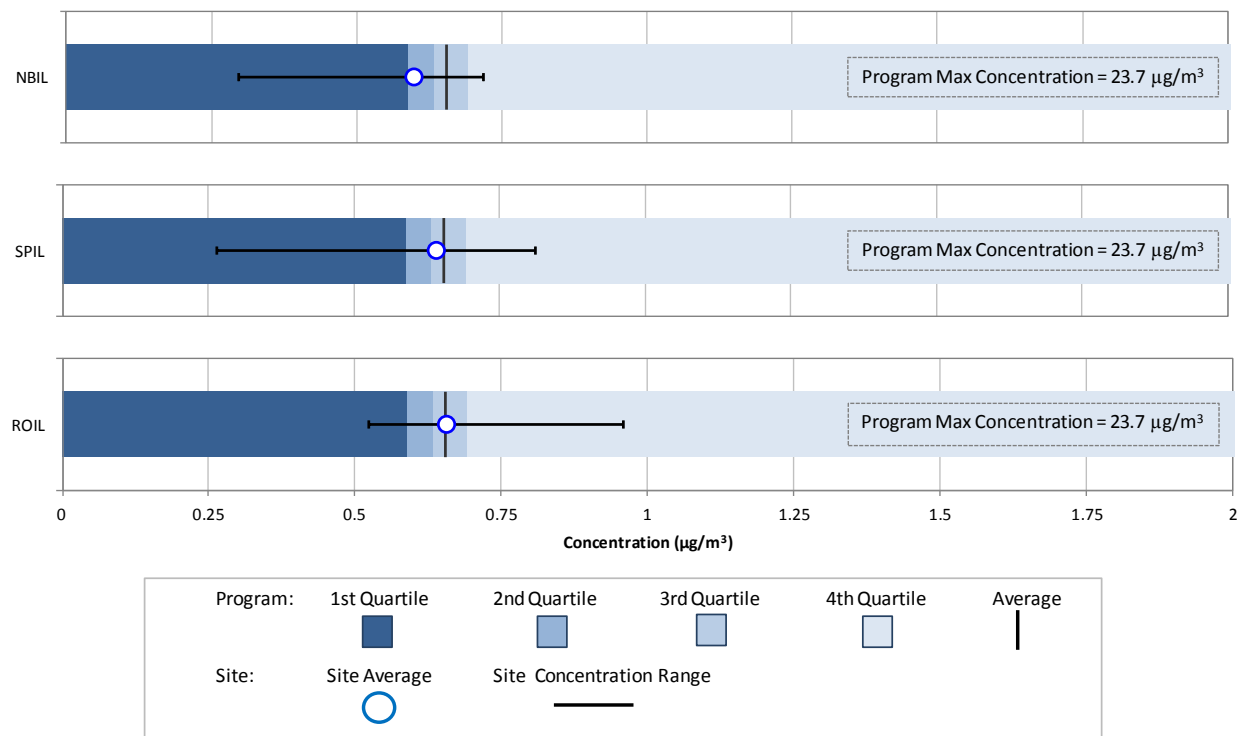


Figure 12-15. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations

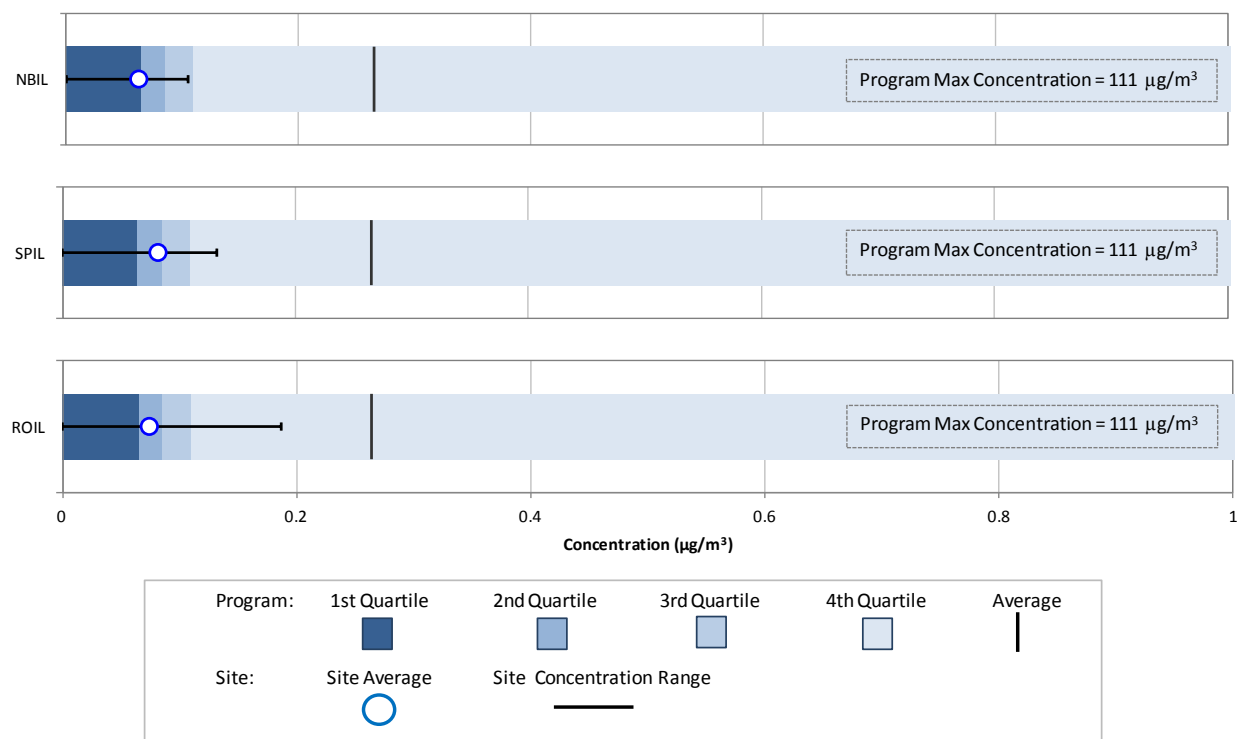


Figure 12-16. Program vs. Site-Specific Average Ethylbenzene Concentration

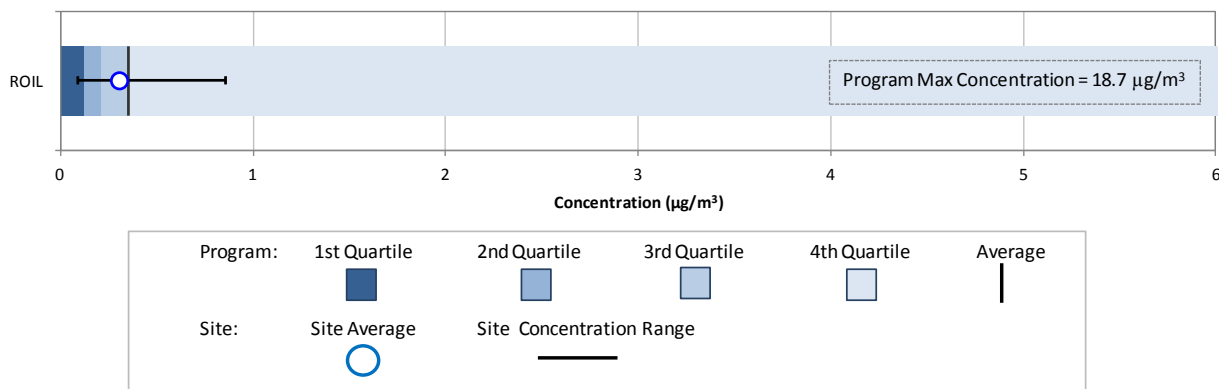


Figure 12-17. Program vs. Site-Specific Average Fluoranthene Concentration

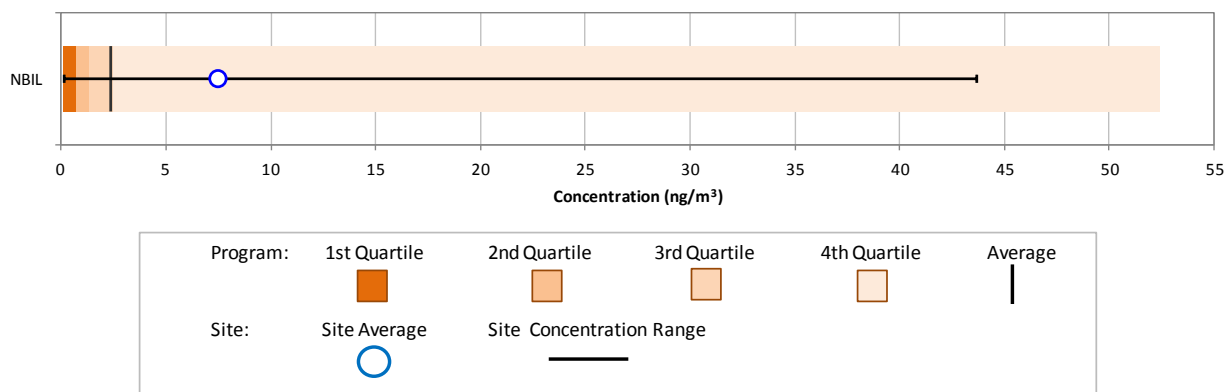


Figure 12-18. Program vs. Site-Specific Average Fluorene Concentration

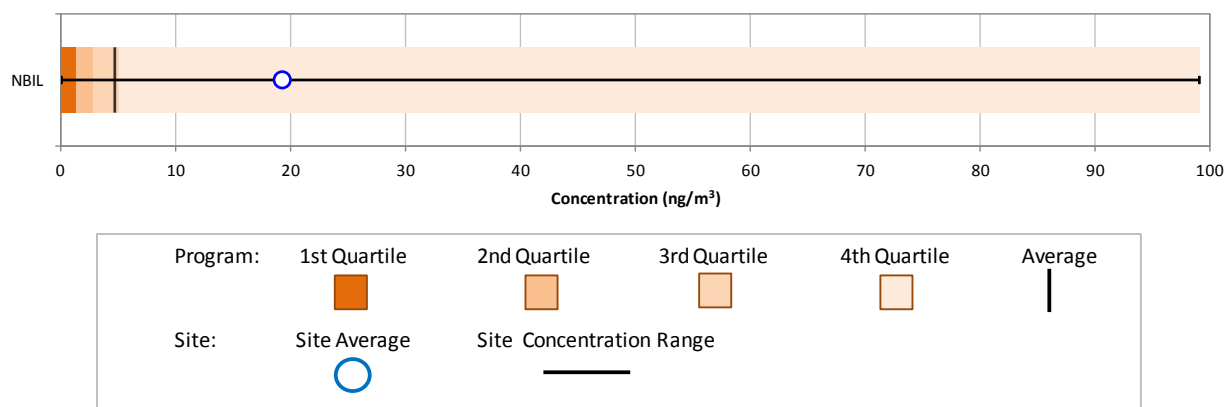


Figure 12-19. Program vs. Site-Specific Average Formaldehyde Concentrations

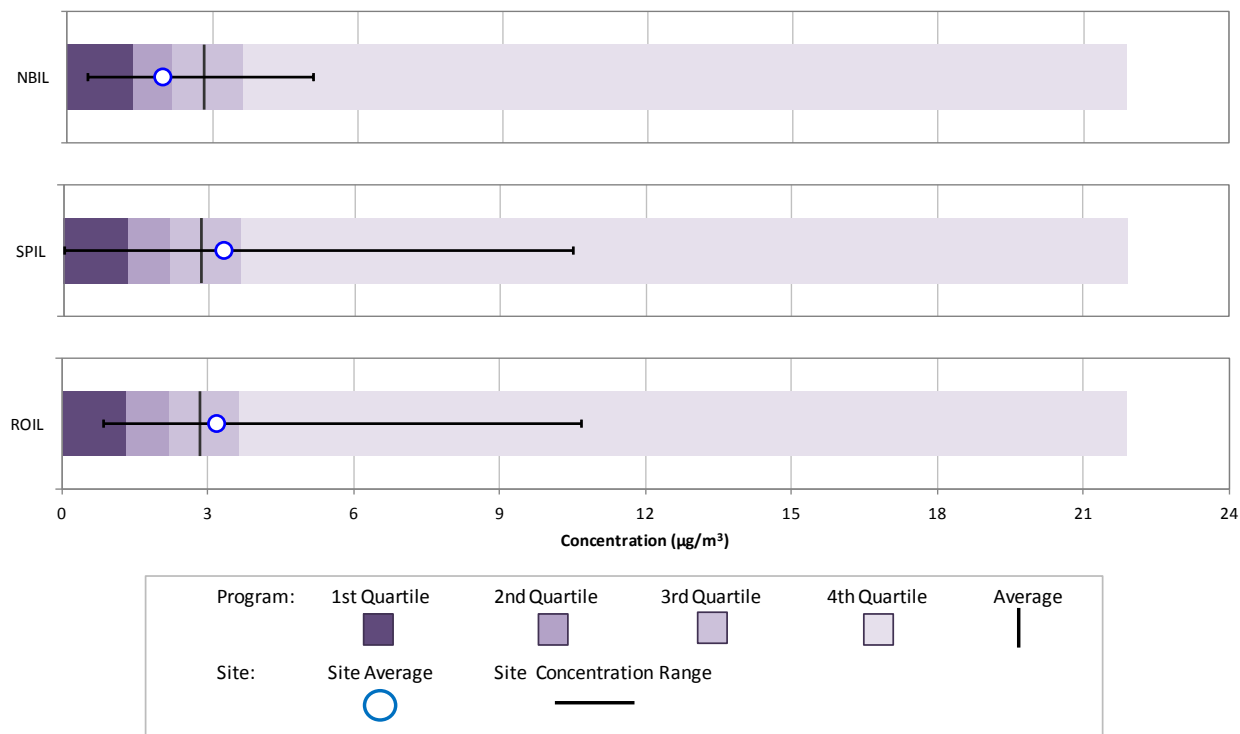


Figure 12-20. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentrations

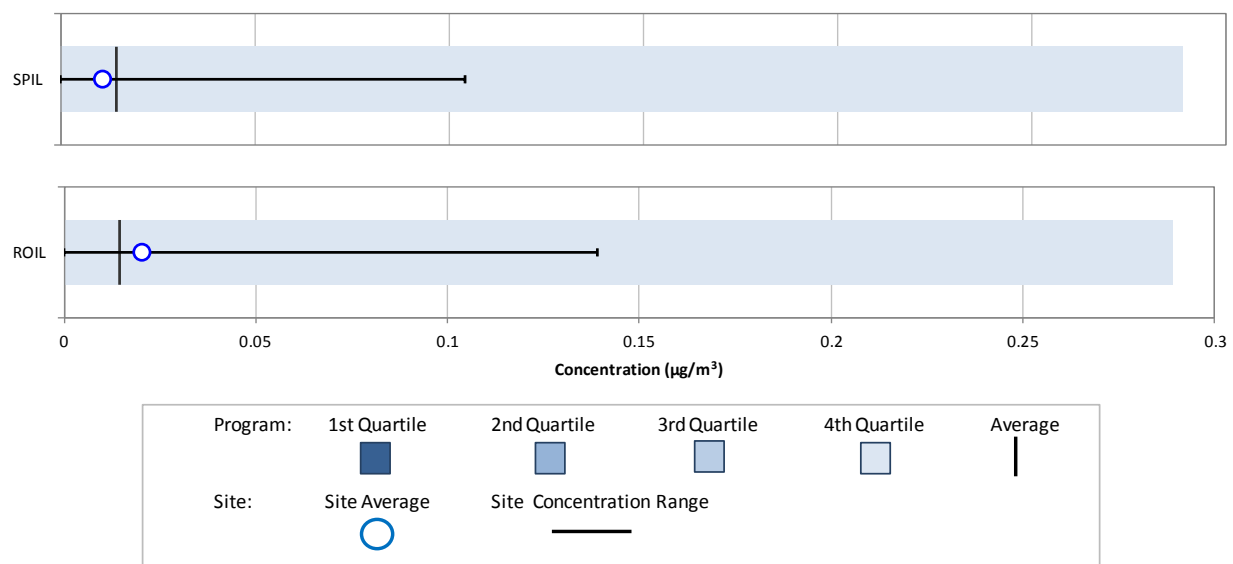


Figure 12-21. Program vs. Site-Specific Average Naphthalene Concentration

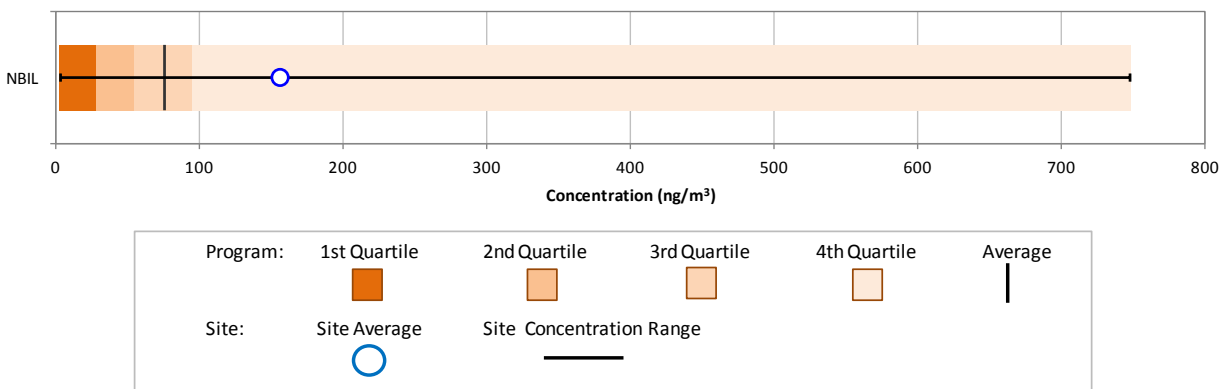
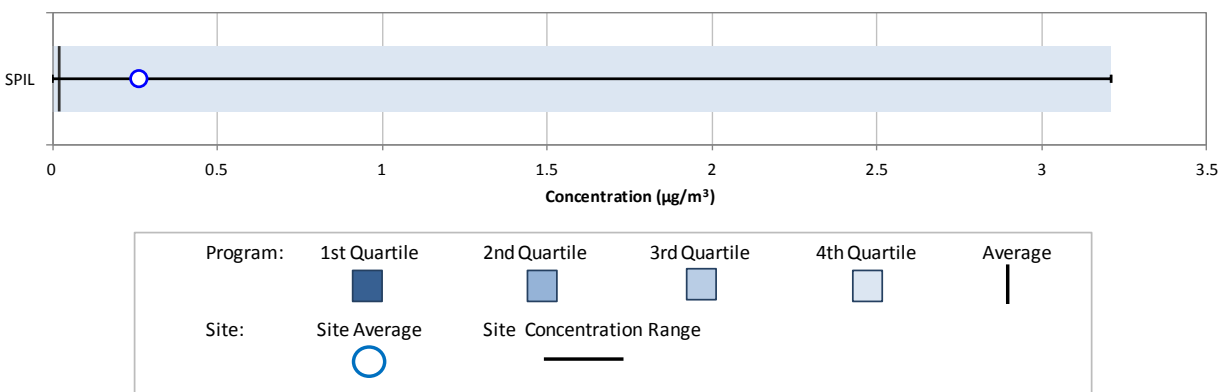


Figure 12-22. Program vs. Site-Specific Average Trichloroethylene Concentration



Observations from Figures 12-9 through 12-22 include the following:

- Figure 12-9 is the box plot for acenaphthene for NBIL. Note that the program-level maximum concentration (123 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 80 ng/m^3 . The maximum acenaphthene concentration measured at NBIL is the maximum concentration measured across the program. NBIL's annual average acenaphthene concentration is more than five times the program-level average concentration. More than half of NBIL's acenaphthene measurements are greater than the program-level average concentration. Note that the program-level average is greater than the program-level third quartile, an indication that the measurements at the upper end of the concentration range are driving the program-level average. Although non-detects were measured across the program, none were measured at NBIL.
- Figure 12-10 presents the acetaldehyde box plots for all three Illinois sites. The box plots show that the maximum acetaldehyde concentration across the program was measured at SPIL; a similar observation was made in the 2012 NMP report. However, the minimum acetaldehyde concentration measured across the program was also measured at SPIL. The annual average acetaldehyde concentration for

SPIL is the same as the annual average acetaldehyde concentration for NBIL. These annual averages are greater than the program-level average concentration and just greater than the program-level third quartile. The range of acetaldehyde concentrations measured at ROIL is smaller than the range of measurements from the Chicago sites and ROIL's annual average is similar to the program-level average concentration.

- Figure 12-11 is the box plot for arsenic, which was measured at NBIL only. The box plot shows the maximum concentration measured at NBIL is considerably less than the maximum concentration measured across the program. The annual average concentration for NBIL is just less than the program-level average concentration. While a few non-detects of arsenic were measured among sites sampling PM₁₀ metals, none were measured at NBIL.
- Figure 12-12 presents the box plots for benzene for all three sites. Similar to the box plot for acenaphthene, the program-level maximum benzene concentration (43.5 µg/m³) is not shown directly on the box plots as the scale has been reduced to 12 µg/m³ in Figure 12-12 to allow for the observation of data points at the lower end of the concentration range. The range of concentrations measured at SPIL and ROIL are similar to each other and twice the range of concentrations measured at NBIL. NBIL's annual average benzene concentration is less than the program-level median concentration and is the third lowest among NMP sites sampling this pollutant. SPIL's annual average benzene concentration is similar to the program-level average concentration while ROIL's annual average is greater than the program-level average concentration and third quartile. Among the NMP sites sampling benzene, ROIL's annual average ranks 13th.
- Figure 12-13 presents the box plots for 1,3-butadiene for all three sites. Again, the program-level maximum 1,3-butadiene concentration (21.5 µg/m³) is not shown directly on the box plots as the scale has been reduced to 1.5 µg/m³ in Figure 12-13 to allow for the observation of data points at the lower end of the concentration range. The range of 1,3-butadiene concentrations is largest for SPIL and smallest for ROIL. In fact, all of the 1,3-butadiene concentrations measured at ROIL are less than the program-level average concentration. However, the program-level average concentration is greater than the program-level third quartile, an indication that the measurements at the upper end of the concentration range are driving the program-level average. The annual average concentration of 1,3-butadiene is highest for SPIL and lowest for NBIL among the Illinois sites. ROIL's annual average concentration is similar to the program-level median concentration while NBIL's annual average is similar to the program-level first quartile.
- Figure 12-14 presents the box plots for carbon tetrachloride. The scale of these box plots have also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum carbon tetrachloride concentration (23.7 µg/m³) is considerably greater than the majority of measurements. Figure 12-14 shows that maximum carbon tetrachloride concentrations measured at the Illinois sites are considerably less than the

program-level maximum concentration. The minimum concentrations measured at NBIL and SPIL are roughly half the minimum concentration measured at ROIL. The annual average carbon tetrachloride concentration for ROIL is similar to the program-level average concentration. While the annual averages for NBIL and SPIL are both less than the program-level average concentration, NBIL's annual average concentration is similar to the program-level first quartile.

- The scale of the box plot in Figure 12-15 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum 1,2-dichloroethane concentration ($111 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Note that all of the concentrations of 1,2-dichloroethane measured at the Illinois sites are less than the program-level average concentration of $0.26 \mu\text{g}/\text{m}^3$. The annual average concentrations for the three Illinois sites are less than the program-level median concentration, with NBIL's annual average concentration just less than the program-level first quartile. This is another example of measurements at the upper end of the concentration range driving the program-level average concentration, as the program-level average is more than twice the program-level third quartile.
- Figure 12-16 is the box plot for ethylbenzene for ROIL, the only Illinois site for which this is a pollutant of interest. The scale of the box plot in Figure 12-16 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum ethylbenzene concentration ($18.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Figure 12-16 shows that all of the ethylbenzene concentrations measured at ROIL are less than $1 \mu\text{g}/\text{m}^3$. ROIL's annual average concentration of ethylbenzene is just less than the program-level average concentration.
- Figure 12-17 presents the box plot for fluoranthene for NBIL. This box plot shows that the maximum concentration of fluoranthene across the program was not measured at NBIL, although several of the highest fluoranthene concentrations across the program were measured at NBIL, as discussed in the previous section. The annual average concentration of fluoranthene for NBIL is more than three times the program-level average concentration.
- Figure 12-18 presents the box plot for fluorene for NBIL. This box plot shows that the maximum concentration of fluorene across the program was measured at NBIL, as discussed in the previous section. The annual average concentration of fluorene for NBIL is more than four times the program-level average concentration. NBIL is one of only two NMP sites with fluorene concentrations greater than $35 \text{ ng}/\text{m}^3$; of the 20 fluorene concentrations greater than $35 \text{ ng}/\text{m}^3$, concentrations measured at NBIL account for 14 of them.
- Figure 12-19 presents the box plots for formaldehyde for all three sites. The maximum formaldehyde concentration measured at ROIL is similar to the maximum formaldehyde concentration measured at SPIL. The annual average formaldehyde concentrations for these two sites are similar to each other and both are greater than the program-level average concentration but less than the

program-level third quartile. The range of formaldehyde concentrations measured at NBIL is considerably smaller. NBIL's annual average formaldehyde concentration is less than the program-level average concentration as well as the program-level median.

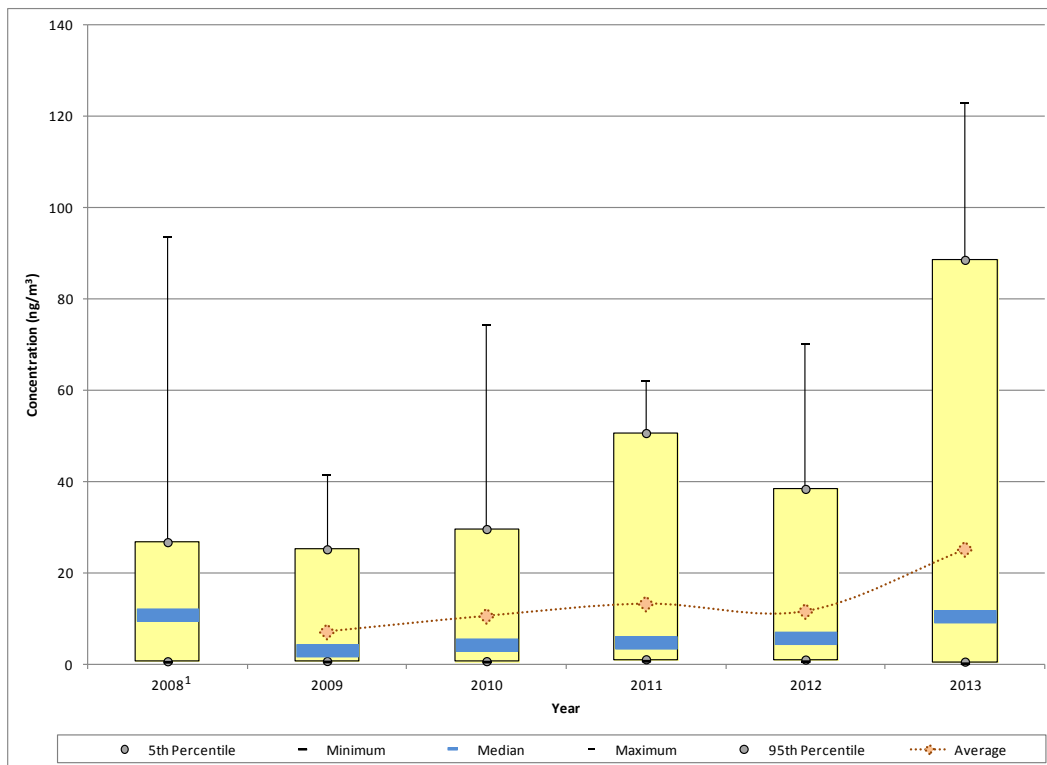
- Figure 12-20 presents the box plots for hexachloro-1,3-butadiene for SPIL and ROIL. The program-level first, second (median), and third quartiles are all zero and therefore not visible on the box plot. This is due to the large number of non-detects of this pollutant across the program (82 percent). Sixty valid VOC samples were collected at SPIL and ROIL; 10 measured detections were measured at SPIL and 15 at ROIL. Thus, many zeroes are substituted into the annual average concentrations for this pollutant. The annual average for SPIL is slightly less than the program-level average while the annual average concentration for ROIL is slightly greater than the program-level average concentration of hexachloro-1,3-butadiene.
- Figure 12-21 is the box plot for naphthalene for NBIL. The maximum naphthalene concentration measured at NBIL (748 ng/m^3) is the maximum concentration measured across the program. The fourth lowest naphthalene concentration across the program was also measured at NBIL. Thus, this site has the largest range of naphthalene measurements across the program. The annual average concentration for NBIL is more than twice the program-level average concentration of naphthalene.
- The first, second, and third quartiles for trichloroethylene are all zero in the box plot for SPIL presented in Figure 12-22 due to the large number of non-detects; thus, only the fourth quartile is visible. The maximum concentration of trichloroethylene across the program was measured at SPIL. The annual average concentration for SPIL ($0.26 \text{ } \mu\text{g/m}^3$) is more than five times greater than the next highest annual average concentration for this pollutant (calculated for S4MO, $0.05 \text{ } \mu\text{g/m}^3$) and an order of magnitude higher than the program-level average concentration ($0.02 \text{ } \mu\text{g/m}^3$).

12.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. NBIL and SPIL have both sampled VOCs under the NMP since 2003. Both sites have also sampled carbonyl compounds since 2005. NBIL has also sampled PM_{10} metals since 2005 and began sampling PAHs under the NMP in 2008. Thus, Figures 12-23 through 12-52 present the 1-year statistical metrics for each of the pollutants of interest first for NBIL, then for SPIL. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range

and percentiles are still presented. Because sampling at ROIL began in 2012, a trends analysis was not performed.

Figure 12-23. Yearly Statistical Metrics for Acenaphthene Concentrations Measured at NBIL



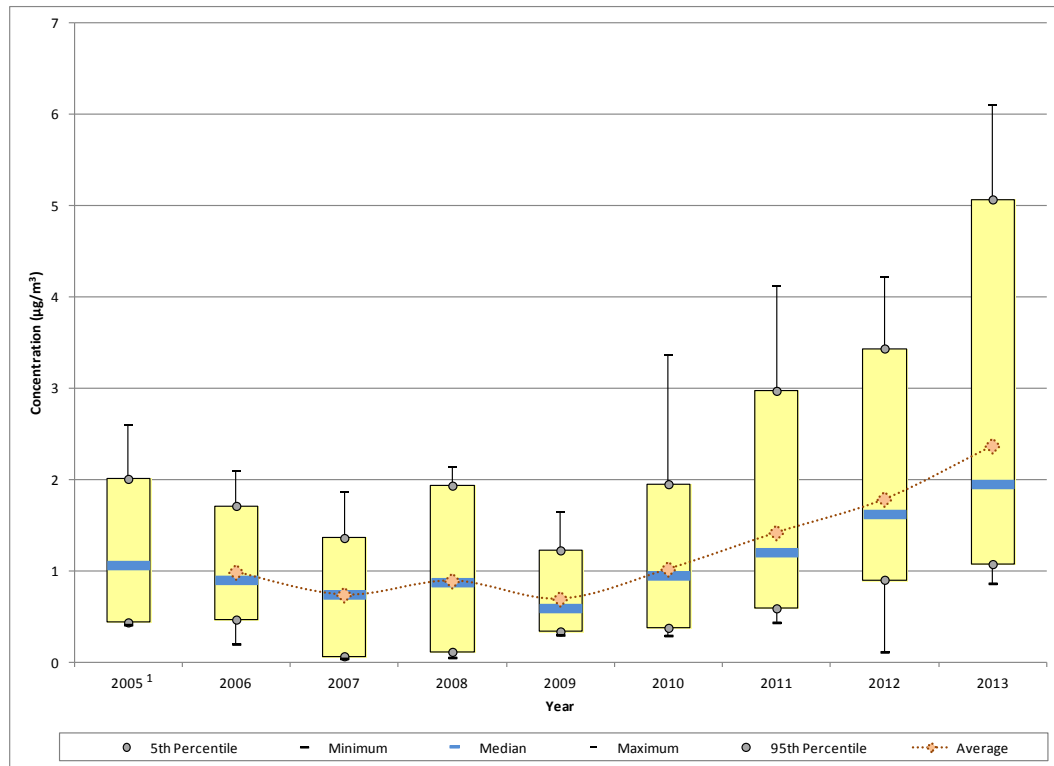
¹ A 1-year average is not presented because sampling under the NMP did not begin until June 2008.

Observations from Figure 12-23 for acenaphthene measurements collected at NBIL include the following:

- Although PAH sampling under the NMP at NBIL began in 2008, sampling did not begin until June; because a full year's worth of data is not available for 2008, a 1-year average is not presented, although the range of measurements is provided.
- The three highest acenaphthene concentrations measured at NBIL were all measured in 2013, and all but one of the six acenaphthene concentrations greater than 75 ng/m³ were measured in 2013, with the other measured in 2008 (93.5 ng/m³).
- The median concentration decreased significantly from 2008 to 2009. This is because there are a greater number of concentrations at the lower end of the concentration range in 2009. Recall, however, that 2008 does not include a full year's worth of sampling. The median concentration increases steadily after 2009 through 2012, after which the median doubles for 2013.
- The 1-year average concentration increases between 2009 and 2011, nearly doubling over this time frame. However, confidence intervals calculated for these averages

indicate that the increase is not statistically significant due to the relatively large amount of variability in the measurements. The 1-year average decreased slightly for 2012, although the median continued to increase. For 2013, the 1-year average concentration more than doubled, with similar increases for the median, 95th percentile, and maximum concentration. Even if the two highest measurements from 2013 were excluded from the calculation, the increase in the 1-year average concentrations from 2012 to 2013 would still represent a nearly 90 percent increase; thus, concentrations were higher overall for 2013.

Figure 12-24. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at NBIL



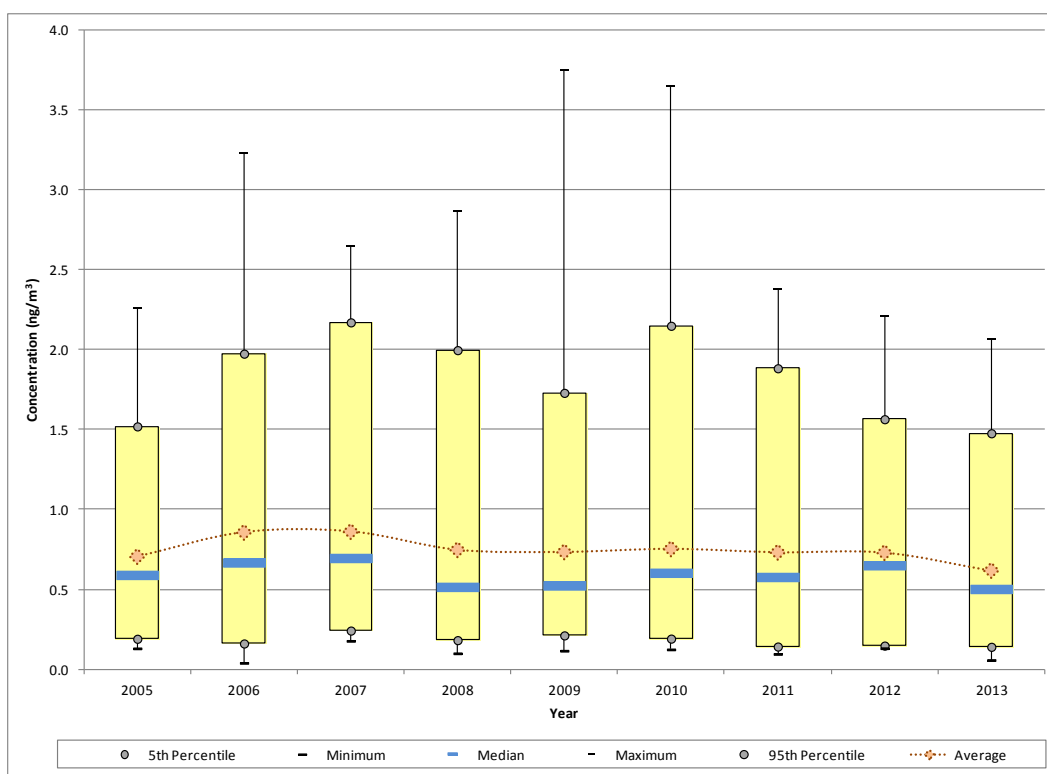
¹ A 1-year average is not presented because sampling under the NMP did not begin until March 2005.

Observations from Figure 12-24 for acetaldehyde measurements collected at NBIL include the following:

- Carbonyl compound sampling at NBIL under the NMP began in March 2005; because a full year's worth of data is not available for 2005, a 1-year average concentration is not presented, although the range of measurements is provided.
- The maximum acetaldehyde concentration measured at NBIL since the onset of sampling ($6.10 \mu\text{g}/\text{m}^3$) was measured in 2013; the seven highest concentrations were all measured at NBIL in 2013. The highest acetaldehyde concentrations were measured in the most recent years; of the 25 acetaldehyde concentrations greater than $3 \mu\text{g}/\text{m}^3$ measured at NBIL, one was measured in 2010, three in 2011, six in 2012, and 15 were measured in 2013.

- Prior to 2010, the 1-year average concentrations were all less than $1 \mu\text{g}/\text{m}^3$, fluctuating between $0.69 \mu\text{g}/\text{m}^3$ (2009) and $0.98 \mu\text{g}/\text{m}^3$ (2006). After 2009, acetaldehyde concentrations measured at NBIL increase significantly as all of the statistical metrics exhibit an increase from 2009 to 2010 and again for 2011, 2012, and 2013 (although the minimum concentration decreased for 2012). The 95th percentile for 2013 is greater than the maximum concentrations measured for all previous years of sampling. The 5th percentile for 2013 is greater than the 1-year average concentrations for each of the earlier years of sampling.
- The increase in the 1-year average concentration of acetaldehyde between 2009 and 2013 represents a 244 percent increase.

Figure 12-25. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at NBIL

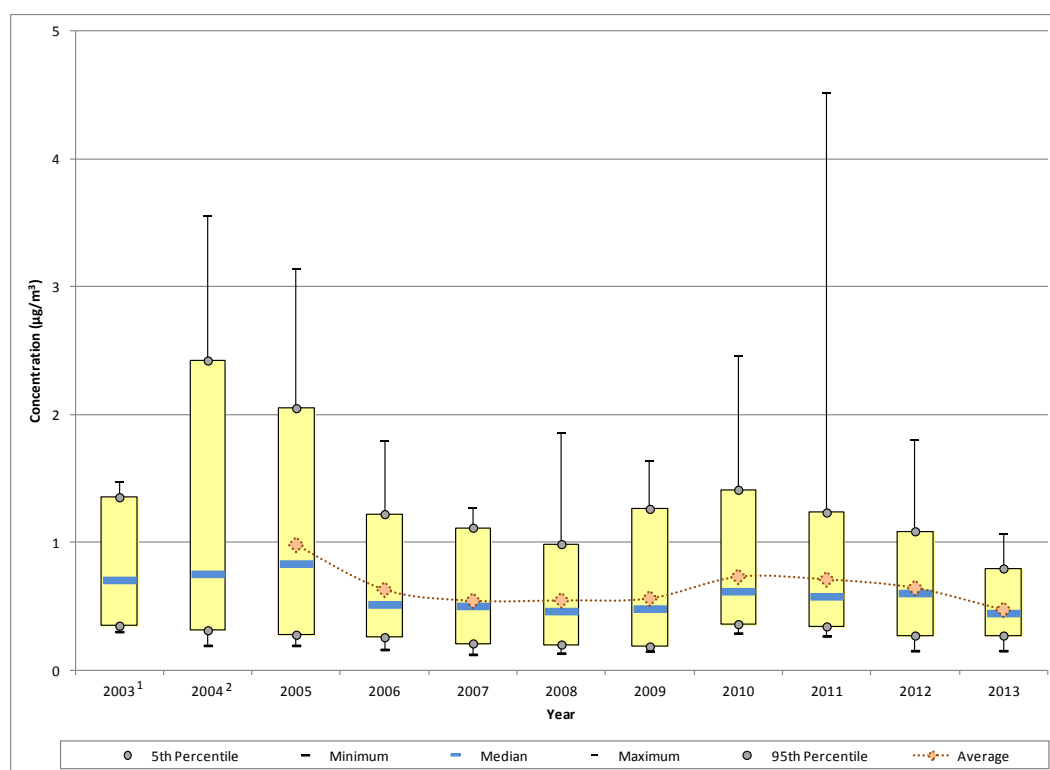


Observations from Figure 12-25 for arsenic (PM_{10}) measurements collected at NBIL include the following:

- Metals sampling at NBIL began in January 2005.
- The maximum arsenic concentration was measured at NBIL on July 12, 2009, although a similar concentration was also measured in 2010. Only four concentrations equal to or greater than $3 \text{ ng}/\text{m}^3$ have been measured at NBIL (one in 2006, one in 2009, and two in 2010).

- Although the statistical parameters representing the upper end of the concentration range have fluctuated somewhat each year, the 1-year average concentrations exhibit relatively little significant change over the course of sampling. The 1-year average concentration increased from 2005 to 2006, reached a maximum for 2007 (0.86 ng/m³), decreased slightly for 2008, after which the 1-year average concentration remained steady through 2012. Between 2008 and 2012, the 1-year average concentrations ranged from 0.73 ng/m³ (2012) to 0.75 ng/m³ (2010). Most of the statistical parameters are at a minimum for 2013, with the 1-year average concentration (0.62 ng/m³) at its lowest since the first year of sampling.
- The minimum concentration for each year is greater than zero, indicating that there were no non-detects of arsenic reported since the onset of metals sampling at NBIL.

Figure 12-26. Yearly Statistical Metrics for Benzene Concentrations Measured at NBIL



¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

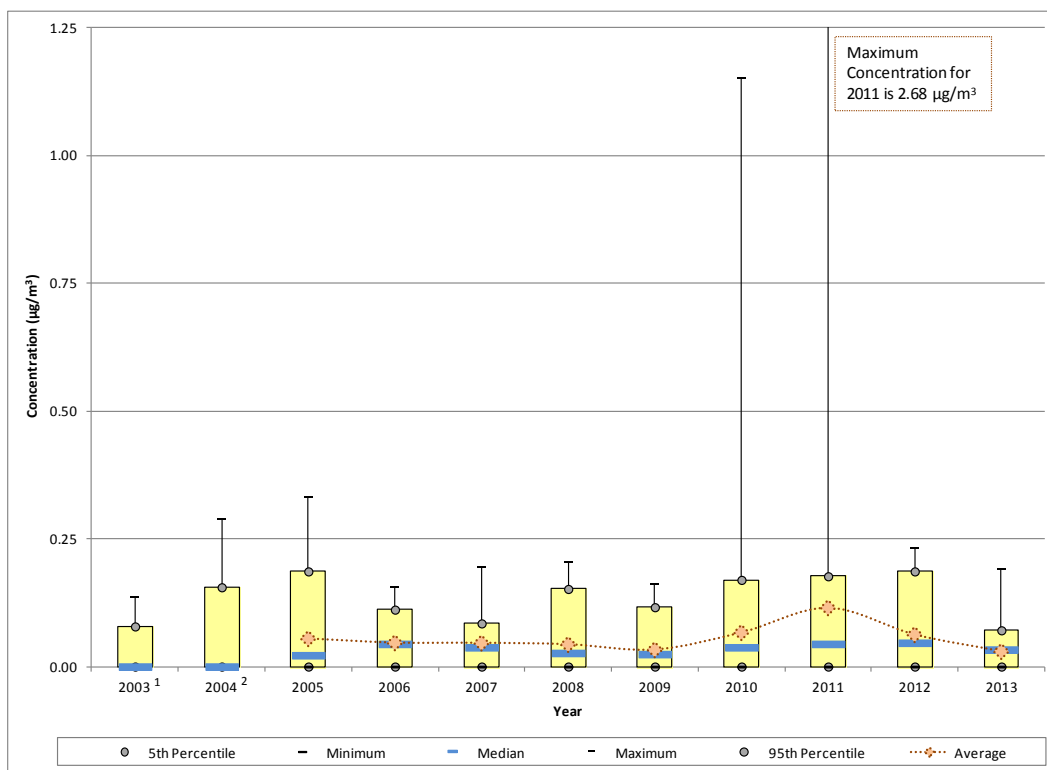
² A 1-year average is not presented because there was a gap in sampling from late October 2004 until late December 2004.

Observations from Figure 12-26 for benzene measurements collected at NBIL include the following:

- Although sampling for VOCs at NBIL began in 2003, sampling under the NMP did not begin until April; because a full year's worth of data is not available for 2003, a 1-year average is not presented, although the range of measurements is provided. In addition, sampling for VOCs was discontinued in October 2004 through the end of the year. Thus, a 1-year average is not presented for 2004 either.

- The maximum benzene concentration ($4.51 \mu\text{g}/\text{m}^3$) was measured on January 9, 2011 and is the only benzene measurement greater than $4 \mu\text{g}/\text{m}^3$ measured at NBIL. Three additional benzene concentrations greater than $3 \mu\text{g}/\text{m}^3$ were measured in 2004 and 2005 and most of the measurements greater than $2 \mu\text{g}/\text{m}^3$ were measured in 2004.
- The 1-year average concentration decreased significantly from 2005 to 2006, and decreased slightly for 2007, then remained steady through 2009. All of the statistical parameters exhibit increases from 2009 to 2010. Although the maximum concentration nearly doubled from 2010 to 2011, the rest of the statistical parameters decreased for 2011. This decreasing continued into 2012 (although the median concentration actually increased slightly) and 2013.
- With the exceptions of the minimum and 5th percentile, the statistical parameters are each at a minimum for 2013; 2013 is the first year the 1-year average concentration is less than $0.5 \mu\text{g}/\text{m}^3$.

Figure 12-27. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at NBIL



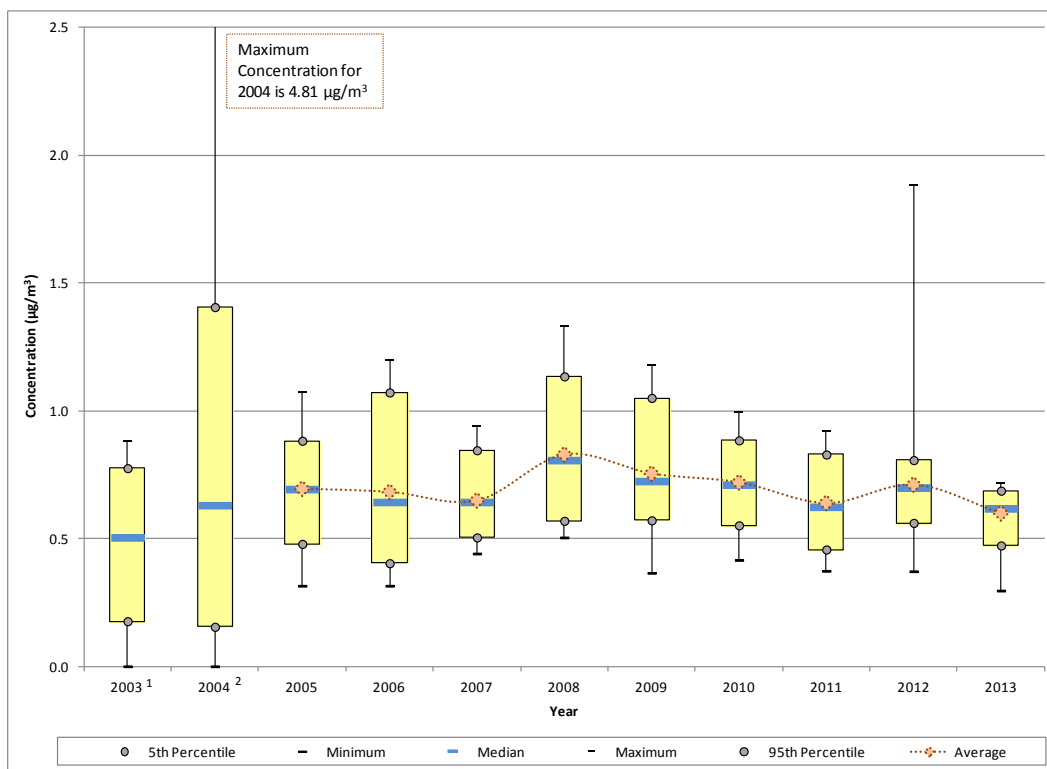
¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

² A 1-year average is not presented because there was a gap in sampling from late October 2004 until late December 2004.

Observations from Figure 12-27 for 1,3-butadiene measurements collected at NBIL include the following:

- The maximum 1,3-butadiene concentration was measured on the same day as the maximum benzene concentration, January 9, 2011 ($2.68 \mu\text{g}/\text{m}^3$). Only three concentrations greater than $1 \mu\text{g}/\text{m}^3$ have been measured at NBIL, two in 2011 and one in 2010. All other concentrations of 1,3-butadiene measured at NBIL are less than $0.35 \mu\text{g}/\text{m}^3$.
- For each year shown, the minimum and 5th percentile are zero, indicating the presence of non-detects (at least 5 percent of the measurements). For the first 2 years of sampling, the median concentration is also zero, indicating that at least half of the measurements were non-detects. The number of non-detects reported has fluctuated over the years of sampling, from as high as 88 percent (2004) to as low as 7 percent (2007), although the percentage of non-detects has been increasing slightly each year since 2007, with 38 percent of measurements as non-detects for 2013.
- The 1-year average concentration decreased slightly between 2005 and 2009, although the changes are not significant. From 2009 to 2010, the 1-year average doubled, and then nearly doubled again for 2011. However, there is a significant amount of variability associated with these measurements, based on the confidence intervals. Even with the relatively high concentrations measured in 2010 and 2011, the 95th percentile changed only slightly, indicating that the majority of the measurements were within the same range. If the three outlier concentrations measured in 2010 and 2011 were excluded from the calculations, the 1-year average concentrations would still exhibit increasing trend between 2009 and 2012, but they would be less dramatic.
- The range within which the majority of concentrations fall, as determined by the 5th and 95th percentiles, is at a minimum for 2013, as is the 1-year average concentration.

Figure 12-28. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at NBIL



¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

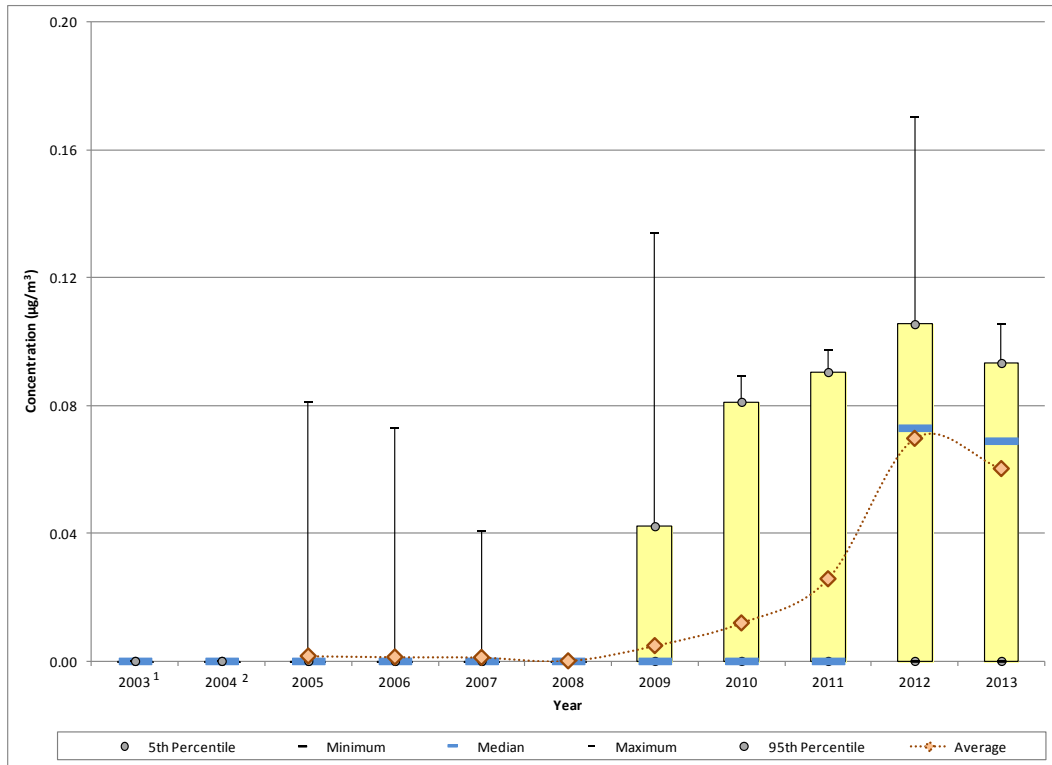
² A 1-year average is not presented because there was a gap in sampling from late October 2004 until late December 2004.

Observations from Figure 12-28 for carbon tetrachloride measurements collected at NBIL include the following:

- The maximum concentration of carbon tetrachloride was measured in 2004 ($4.81 \mu\text{g}/\text{m}^3$). Only one additional measurement greater than $1.5 \mu\text{g}/\text{m}^3$ has been measured ($1.88 \mu\text{g}/\text{m}^3$ in 2012).
- Five non-detects of carbon tetrachloride have been measured at NBIL. All of these were measured during the first 2 years of sampling (two in 2003 and three in 2004).
- After a slight decreasing trend between 2005 and 2007, the 1-year average concentration increased significantly for 2008. The 1-year average concentration exhibits a decreasing trend after 2008 that continued through 2011. After exhibiting an increase for 2012, the 1-year average concentration is at a minimum for 2013 ($0.60 \mu\text{g}/\text{m}^3$). The 1-year average concentrations presented range from $0.60 \mu\text{g}/\text{m}^3$ (2013) to $0.83 \mu\text{g}/\text{m}^3$ (2008), with most of the 1-year averages falling between $0.65 \mu\text{g}/\text{m}^3$ and $0.75 \mu\text{g}/\text{m}^3$. The median concentration exhibits a similar pattern.
- The difference between the minimum and maximum concentrations is at a minimum for 2013 as is the difference between the 5th and 95th percentiles. The differences in these parameters has generally been decreasing over the last few years of sampling,

indicating that the level of variability within the carbon tetrachloride measurements is decreasing.

Figure 12-29. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at NBIL



¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

² A 1-year average is not presented because there was a gap in sampling from late October 2004 until late December 2004.

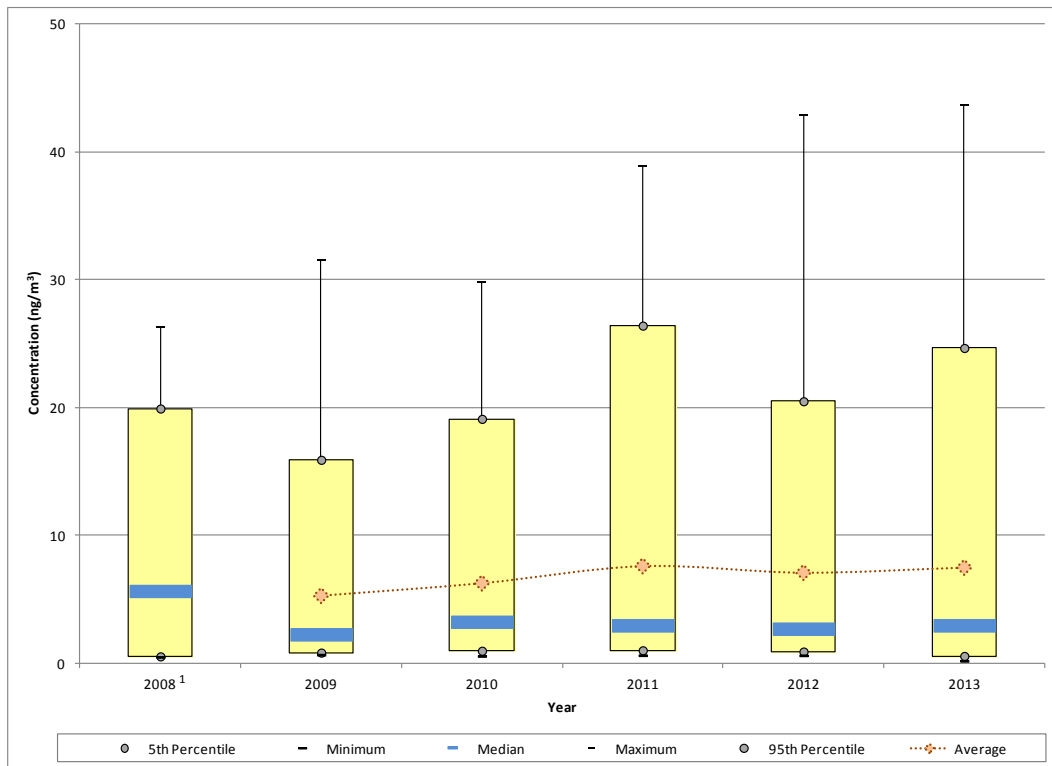
Observations from Figure 12-29 for 1,2-dichloroethane measurements collected at NBIL include the following:

- There were no measured detections of 1,2-dichloroethane in 2003, 2004, or 2008. The number of non-detects between 2005 and 2007 was greater than 95 percent. Thus, the minimum, 5th percentile, median, and in some cases the 1-year average concentrations, were zero between 2003 and 2008. The median concentration is zero through 2011, indicating that at least half of the measurements are non-detects.
- The number of non-detects began to decrease starting with 2009 and continued through 2012. The percentage of non-detects was at a minimum for 2012 (13 percent). As the number of measured detections increased, the 1-year average concentrations exhibit significant increases.
- The median concentration is greater than zero for the first time for 2012 and is also greater than the 1-year average concentration. This is because the eight non-detects (or zeros) factored into the 1-year average concentration are pulling the average down

(in the same manner that a maximum or outlier concentration can drive the average up) and are not contributing to the majority of measurements. This is also true for 2013.

- Each of the statistical parameters except the minimum and 5th percentile exhibit slight decreases for 2013.

Figure 12-30. Yearly Statistical Metrics for Fluoranthene Concentrations Measured at NBIL



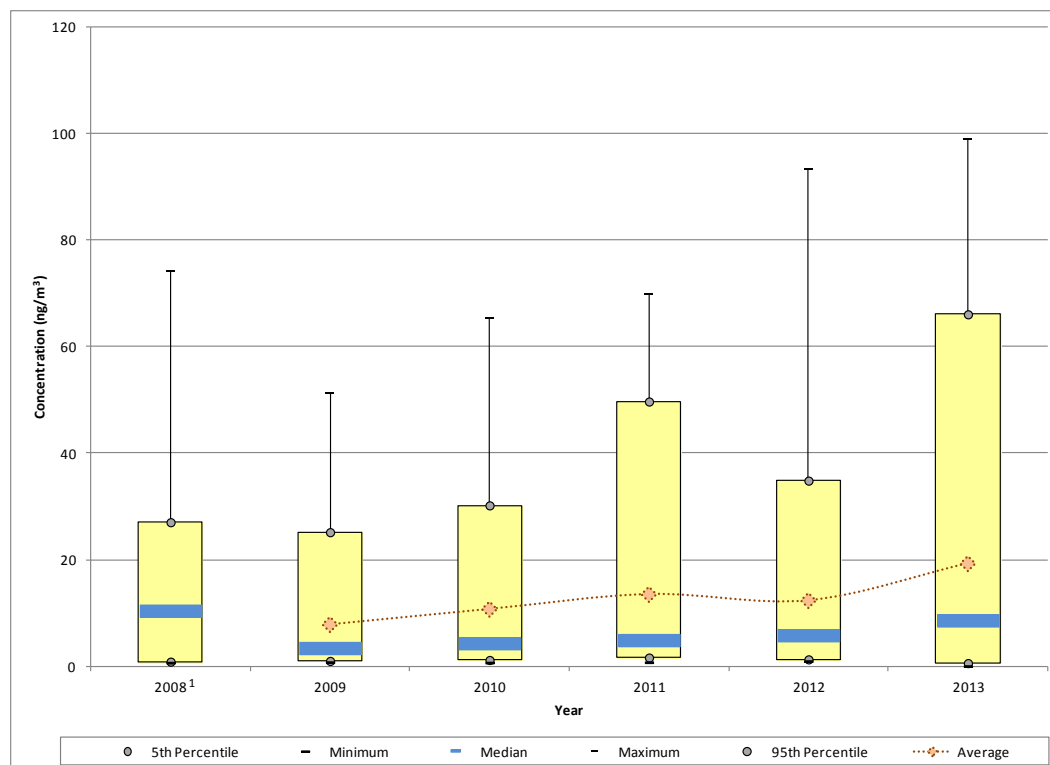
¹ A 1-year average is not presented because sampling under the NMP did not begin until June 2008.

Observations from Figure 12-30 for fluoranthene measurements collected at NBIL include the following:

- The maximum fluoranthene concentration was measured at NBIL on July 21, 2013 (43.7 ng/m³), although two similar concentrations were also measured in 2012 and 2013. All but one of the seven fluoranthene concentrations greater than 30 ng/m³ have been measured since 2011.
- The median concentration decreased significantly from 2008 to 2009. This is because there is a greater number of fluoranthene concentrations at the lower end of the concentration range for 2009, despite the higher maximum concentration measured in 2009. The number of measurements less than 2 ng/m³ tripled from 2008 to 2009, accounting for 25 percent of measurements in 2008 compared to 45 percent for 2009. Recall, however, that 2008 does not include a full year's worth of sampling. The median fluoranthene concentrations shown after 2009 vary little.

- Like acenaphthene, the 1-year average concentration of fluoranthene increases between 2009 and 2011, decreases slightly for 2012, then increases slightly for 2013. However, confidence intervals calculated for these averages indicate that the changes are not statistically significant due to the relatively large amount of variability in the measurements.

Figure 12-31. Yearly Statistical Metrics for Fluorene Concentrations Measured at NBIL



¹ A 1-year average is not presented because sampling under the NMP did not begin until June 2008.

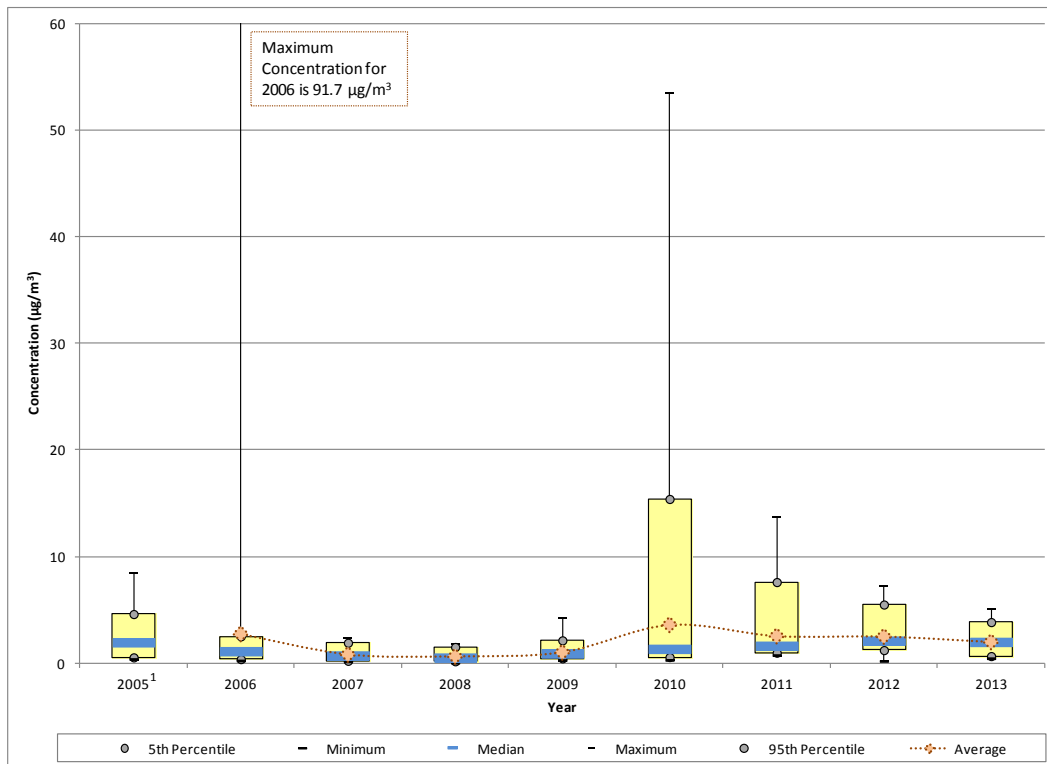
Observations from Figure 12-31 for fluorene measurements collected at NBIL include the following:

- The statistical patterns for fluorene resemble the statistical patterns shown on the trends graph for fluoranthene.
- The median concentration of fluorene also decreased significantly from 2008 to 2009 due to the number of fluorene concentrations at the lower end of the concentration range for 2009.
- Like acenaphthene and fluoranthene, the 1-year average concentration of fluorene increases between 2009 and 2011, decreases slightly for 2012, then increases for 2013. Confidence intervals calculated for these averages indicate that the changes are not statistically significant due to the relatively large amount of variability in the measurements. The range of fluorene measurements spans two orders of magnitude

for each year. For example, the minimum and maximum concentrations for 2012 are 0.93 ng/m³ and 93.4 ng/m³, respectively.

- Since 2009, the maximum concentration of fluorene measured at NBIL has nearly doubled. The 95th percentile also has an increasing trend between 2009 and 2013, although a decrease is shown for 2012.

Figure 12-32. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at NBIL



¹ A 1-year average is not presented because sampling under the NMP did not begin until March 2005.

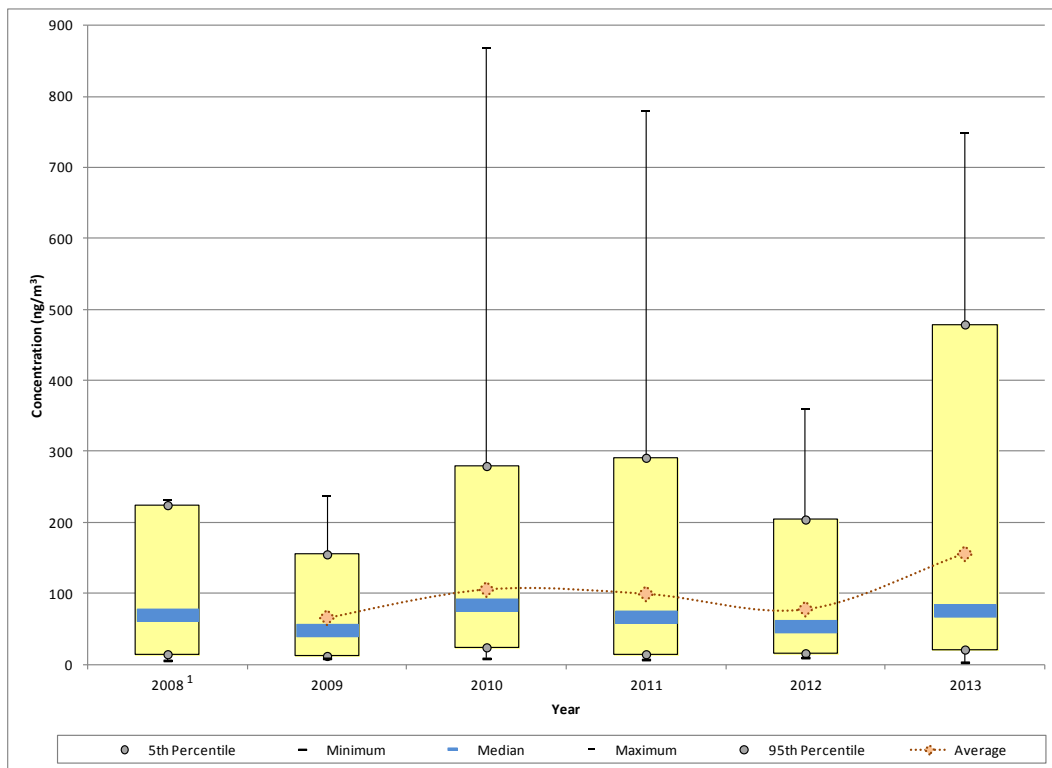
Observations from Figure 12-32 for formaldehyde measurements collected at NBIL include the following:

- The maximum formaldehyde concentration was measured on January 5, 2006 (91.7 µg/m³). The next five highest concentrations, ranging from 14.4 µg/m³ to 53.5 µg/m³, were all measured in 2010. The only other formaldehyde concentration greater than 10 µg/m³ was measured in 2011 (13.7 µg/m³).
- The maximum concentration measured in 2006 is 20 times higher than the next highest concentration measured that year (4.46 µg/m³). The magnitude of this outlier explains why the 1-year average concentration is greater than the 95th percentile for 2006.
- The statistical metrics for 2010 are also affected by the higher concentrations; however, concentrations measured this year are higher overall, as indicated by seven-

fold increase in the 95th percentile. Although difficult to discern in Figure 12-32, the 1-year average concentration more than tripled from 2009 to 2010 and the median increased by 50 percent. The concentrations measured in 2011 were less than those measured in 2010, although still greater than most years.

- Although the maximum concentration measured in 2012 is less than the 95th percentile for 2011, the 1-year average concentration did not change significantly for 2012. This is because the number of concentrations in the middle of the concentration range increased. The number of measurements between $2 \mu\text{g}/\text{m}^3$ and $4 \mu\text{g}/\text{m}^3$ nearly doubled from 2011 to 2012.
- The range of formaldehyde concentrations measured at NBIL in 2013 is at its smallest in four years. The difference between the 1-year average and median concentrations is at a minimum for 2013, indicating less variability in the measurements than the preceding years.

Figure 12-33. Yearly Statistical Metrics for Naphthalene Concentrations Measured at NBIL



¹ A 1-year average is not presented because sampling under the NMP did not begin until June 2008.

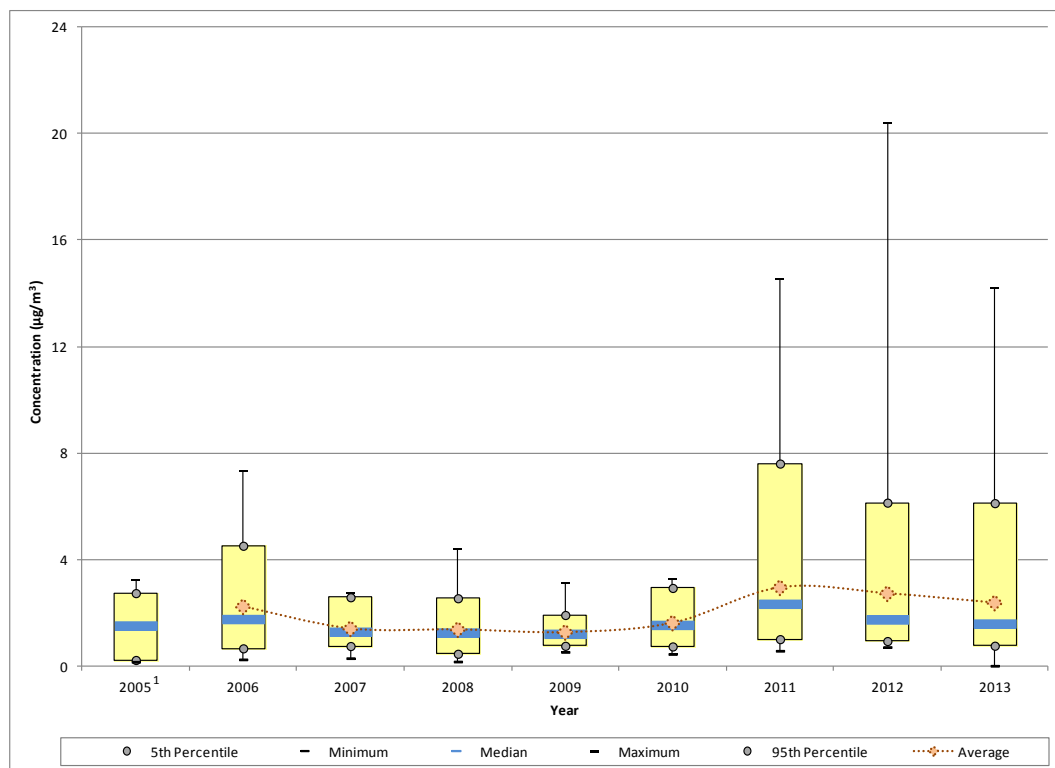
Observations from Figure 12-33 for naphthalene measurements collected at NBIL include the following:

- The maximum naphthalene concentration was measured on September 23, 2010 ($869 \text{ ng}/\text{m}^3$). The second highest concentration measured was measured on October 6, 2011 ($779 \text{ ng}/\text{m}^3$). The next six highest concentrations of naphthalene were all

measured at NBIL in 2013, making 2013 the only year in which multiple naphthalene measurements greater than 400 ng/m³ were measured.

- The central tendency parameters for naphthalene exhibit a similar pattern of changes as those shown on the trends graphs for the other PAH pollutants of interest for NBIL.
- With the exception of the minimum concentration, the statistical parameters exhibit increases for 2013. The 1-year average and maximum concentrations doubled from 2012 to 2013 while the 95th percentile increased by more than 200 ng/m³. These changes from 2012 to 2013 are almost the opposite of those shown from 2011 to 2012, where many of the parameters exhibited substantial decreases.

Figure 12-34. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at SPIL



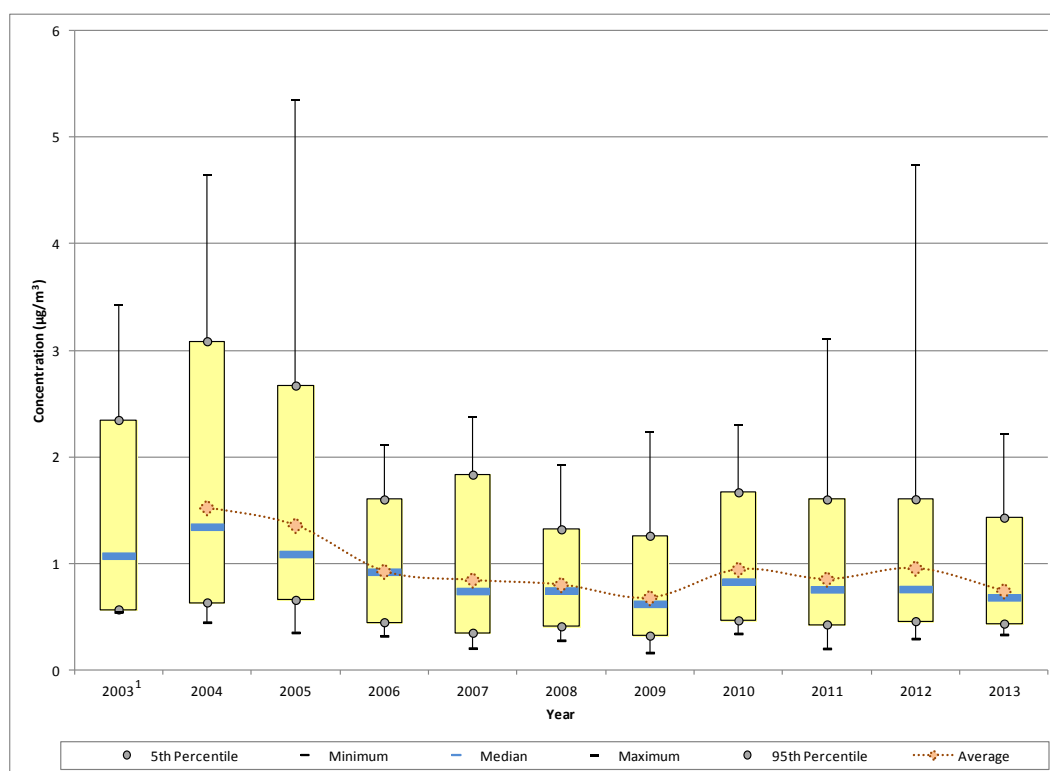
¹ A 1-year average is not presented because consistent sampling did not begin until March 2005.

Observations from Figure 12-34 for acetaldehyde measurements collected at SPIL include the following:

- Although carbonyl compound sampling at SPIL began in early 2005, consistent sampling did not begin until March 2005; because a full year's worth of data is not available for 2005, a 1-year average is not presented, although the range of measurements is provided.

- The maximum acetaldehyde concentration was measured at SPIL on November 17, 2012 (20.4 $\mu\text{g}/\text{m}^3$). Twenty-three of the 25 concentrations of acetaldehyde greater than 5 $\mu\text{g}/\text{m}^3$ were measured in 2011 (eight), 2012 (eight), or 2013 (seven), with the other two measured in 2006.
- The 1-year average concentration decreased significantly from 2006 to 2007, as did most of the other statistical parameters. Between 2007 and 2009, the 1-year average concentration changed little, hovering between 1.25 $\mu\text{g}/\text{m}^3$ and 1.50 $\mu\text{g}/\text{m}^3$. The 1-year average concentration increased in 2010 then increased significantly in 2011. All of the statistical metrics increased for 2011, particularly the maximum and 95th percentile, indicating that the increases shown are not attributable to a few of outliers. As an illustration, the number of measurements greater than 2 $\mu\text{g}/\text{m}^3$ increased from three in 2009 to 15 for 2010 to 40 in 2011.
- The profile of acetaldehyde concentrations measured at SPIL in 2012 and 2013 is more similar to 2011 than other years of sampling, although the measurements exhibit a slight decrease in the magnitude of most of the measurements, as indicated by the slight decrease in the 1-year average concentrations and difference in the 5th and 95th percentiles. Yet these measurements still reflect considerable variability, based on the range of concentrations measured.

Figure 12-35. Yearly Statistical Metrics for Benzene Concentrations Measured at SPIL

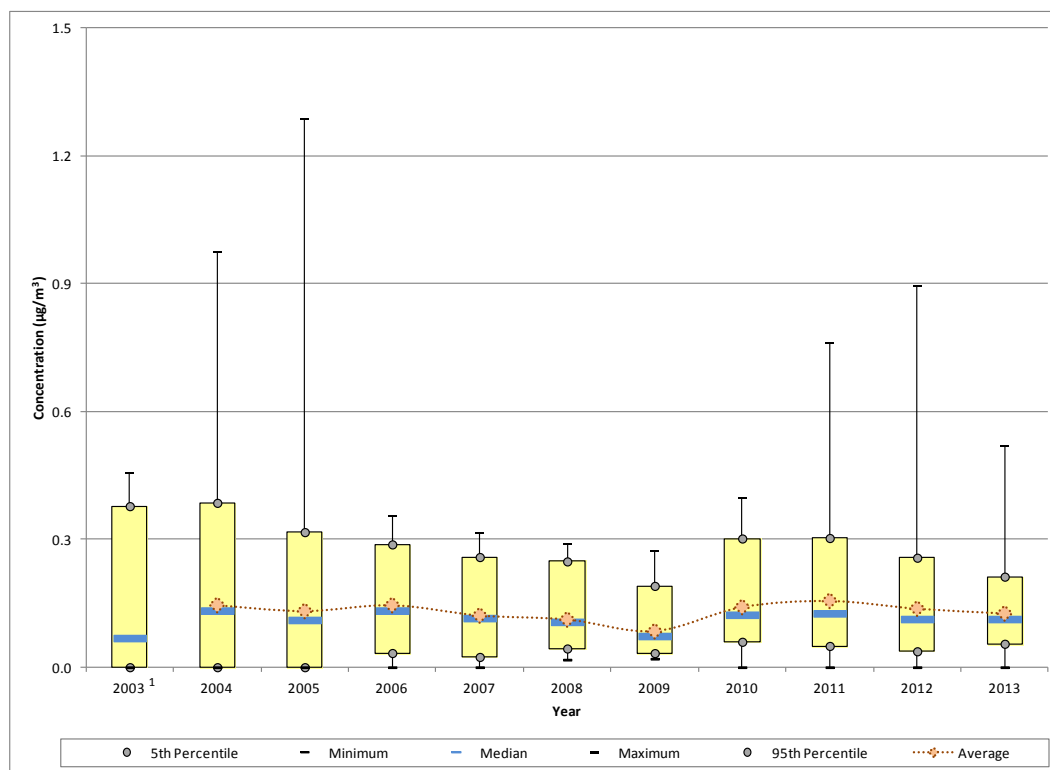


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 12-35 for benzene measurements collected at SPIL include the following:

- Sampling for VOCs at SPIL under the NMP began in April 2003; because a full year's worth of data is not available for 2003, a 1-year average is not presented, although the range of measurements is provided.
- The only two concentrations of benzene greater than $5 \mu\text{g}/\text{m}^3$ were both measured in 2005.
- The 1-year average benzene concentration has a significant decreasing trend over the years between 2004 and 2009. During the last 5 years of sampling, the 1-year average benzene concentration has an undulating pattern, fluctuating between $0.68 \mu\text{g}/\text{m}^3$ (2009) and $0.95 \mu\text{g}/\text{m}^3$ (2012). The median concentration has a similar pattern.
- The majority of benzene concentrations measured at SPIL, as indicated by the 5th and 95th percentiles, fell within roughly the same range between 2010 and 2012. The range of benzene concentrations measured in 2013 is slightly smaller than other recent years.

Figure 12-36. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at SPIL

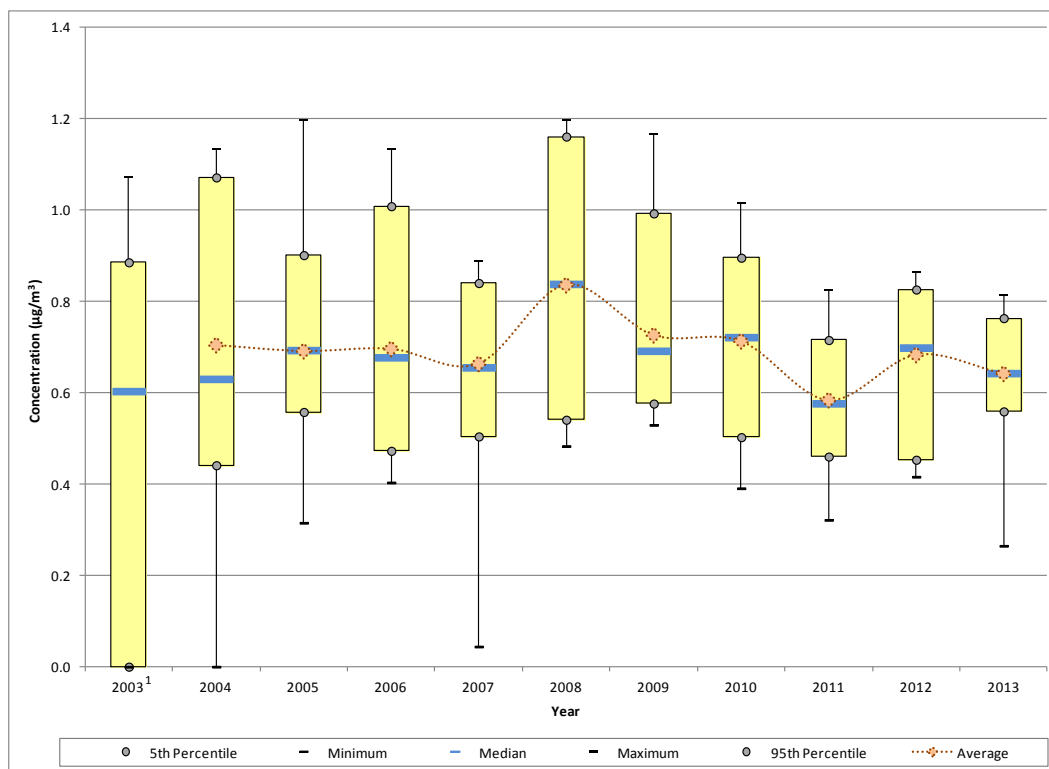


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 12-36 for 1,3-butadiene measurements at SPIL include the following:

- The maximum concentration of 1,3-butadiene was measured at SPIL on February 3, 2005 ($1.29 \mu\text{g}/\text{m}^3$) and is the only measurement greater than $1 \mu\text{g}/\text{m}^3$. In total, only seven concentrations greater than $0.5 \mu\text{g}/\text{m}^3$ have been measured at SPIL, one in 2004, two in 2005, two in 2011, and one each in 2012 and 2013.
- The detection rate for 1,3-butadiene has increased over time, ranging from approximately 45 percent non-detects in 2003 and 2004 to zero in 2008 and 2009, with one non-detect each measured in each of the following years.
- The 1-year average concentrations of 1,3-butadiene changed little between 2004 and 2006, then decreased between 2006 and 2009. The increase in the 1-year average concentration from 2009 to 2010 represents a 67 percent increase and a return to 2006 levels. Although a slight decreasing trend is shown after 2011, there is more variability in the 1,3-butadiene concentrations measured during the last few years of sampling. Despite these changes, most of the 1-year average concentrations shown fall between $0.10 \mu\text{g}/\text{m}^3$ and $0.15 \mu\text{g}/\text{m}^3$, with only the minimum ($0.08 \mu\text{g}/\text{m}^3$ for 2009) and maximum ($0.16 \mu\text{g}/\text{m}^3$ for 2011) falling outside this range.
- The 5th and 95th percentiles indicate the range within which the majority of concentrations fall. This range decreased considerably between 2004 and 2009, increased for 2010 and 2011, then began to decrease again. The difference between these two parameters is at a minimum for 2013.

Figure 12-37. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at SPIL

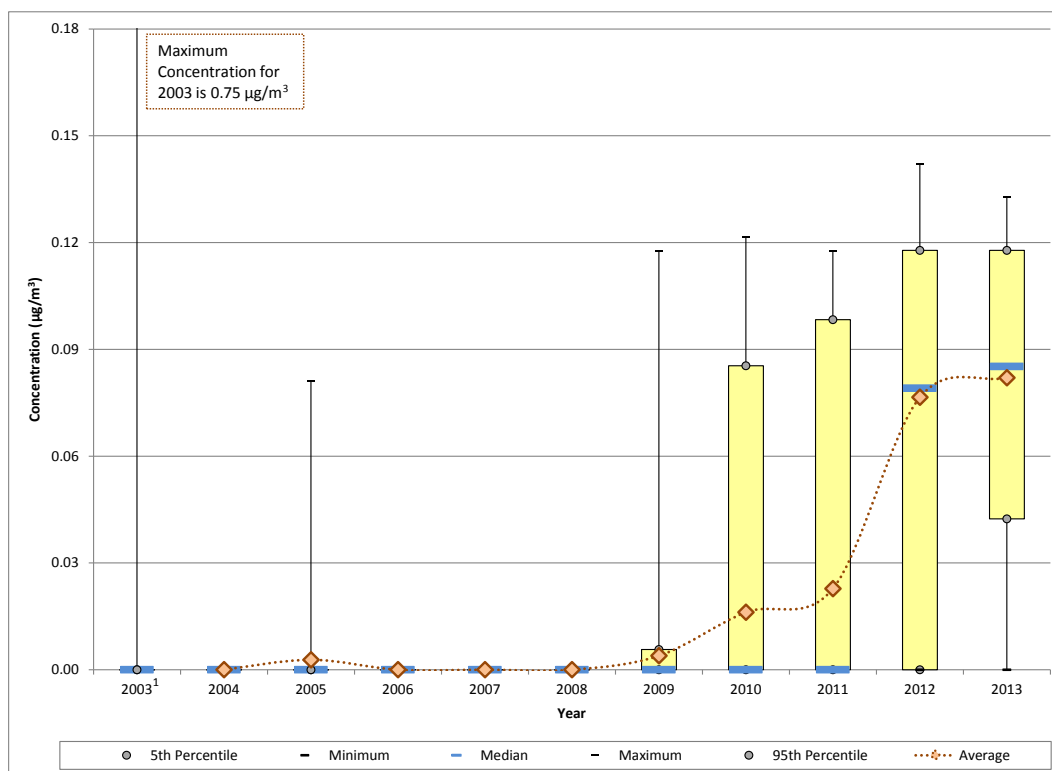


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 12-37 for carbon tetrachloride measurements collected at SPIL include the following:

- The maximum concentration of carbon tetrachloride was measured three times, once in 2005 and twice in 2008 ($1.20 \mu\text{g}/\text{m}^3$).
- Six non-detects of carbon tetrachloride have been measured at SPIL. All of these were measured during the first 2 years of sampling (four in 2003 and two in 2004).
- The 1-year average concentration changed very little between 2004 and 2007, varying between $0.65 \mu\text{g}/\text{m}^3$ and $0.70 \mu\text{g}/\text{m}^3$. The 1-year average then increased significantly for 2008 ($0.84 \mu\text{g}/\text{m}^3$). The 1-year average concentration exhibits a decreasing trend after 2008 that continued through 2011, when the 1-year average is at a minimum ($0.58 \mu\text{g}/\text{m}^3$). The increase shown for 2012 brings the 1-year average carbon tetrachloride concentration near 2010 levels. A similar change was exhibited by the carbon tetrachloride concentrations measured at NBIL for 2012.
- With the exception of the 5th percentile, all the of the statistical parameters exhibit a decrease for 2013. Although the 5th percentile increased considerably in 2013, this is an indication that the variability in the measurements is decreasing as the difference between the 5th and 95th percentiles is at a minimum for 2013.

Figure 12-38. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at SPIL



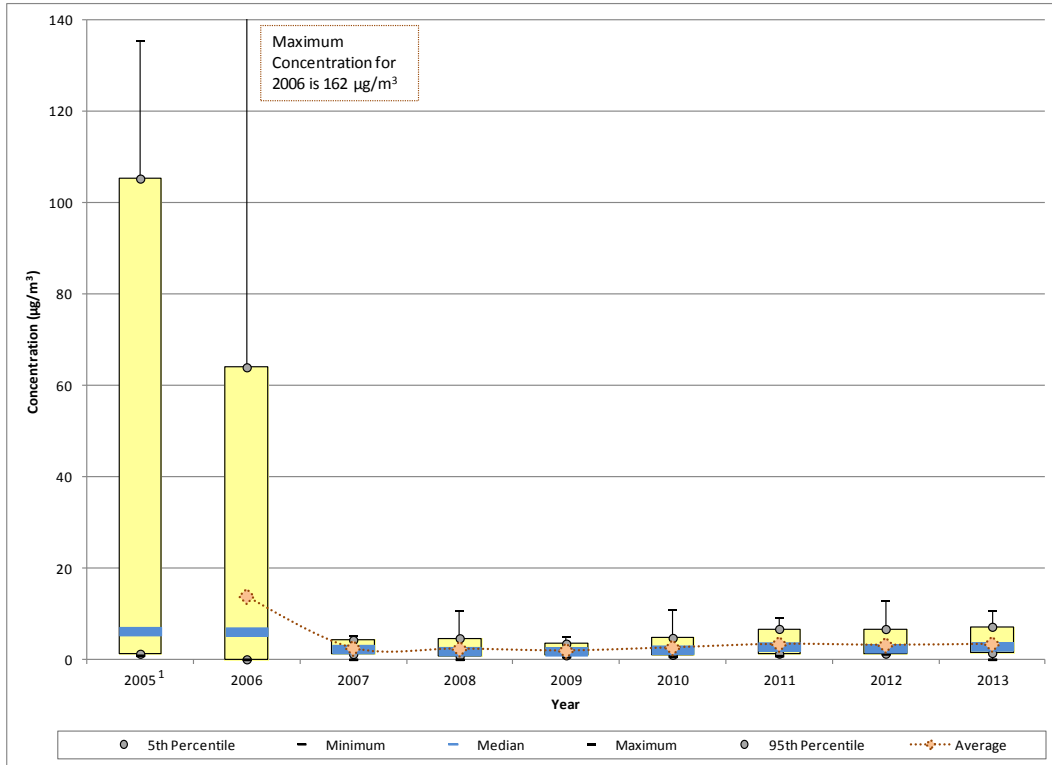
¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 12-38 for 1,2-dichloroethane measurements collected at SPIL include the following:

- There were no measured detections of 1,2-dichloroethane in 2004, 2006, 2007, or 2008. For 2003, 2005, and 2009, the number of non-detects was 95 percent or greater. Thus, the minimum, 5th percentile, median, and in some cases, the 1-year average concentrations were zero through 2009. The median concentration is also zero for 2010 and 2011, indicating that at least half the measurements are non-detects. The percentage of non-detects decreased to 80 percent for 2010 and 73 percent for 2011. For 2012, the percentage of non-detects decreased to 8 percent of samples collected and was at a minimum of 5 percent for 2013, which is the first year that the 5th percentile is greater than zero.
- The maximum concentration of 1,2-dichloroethane was measured at SPIL in 2003 (0.75 $\mu\text{g}/\text{m}^3$). This is the only measured detection for 2003 as all other measurements were non-detects. No other 1,2-dichloroethane concentrations greater than 0.15 $\mu\text{g}/\text{m}^3$ have been measured at SPIL.
- As the number of non-detects decreases and the number of measured detections increases, the statistical parameters begin to increase correspondingly. The median concentration is greater than zero for the first time for 2012. The sharp decrease in the number of non-detects from 73 percent to 8 percent from 2011 to 2012 results in a

sharp increase in the 1-year average concentration shown for 2012. A similar range of 1,2-dichloroethane measurements was collected at SPIL in 2013.

Figure 12-39. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at SPIL

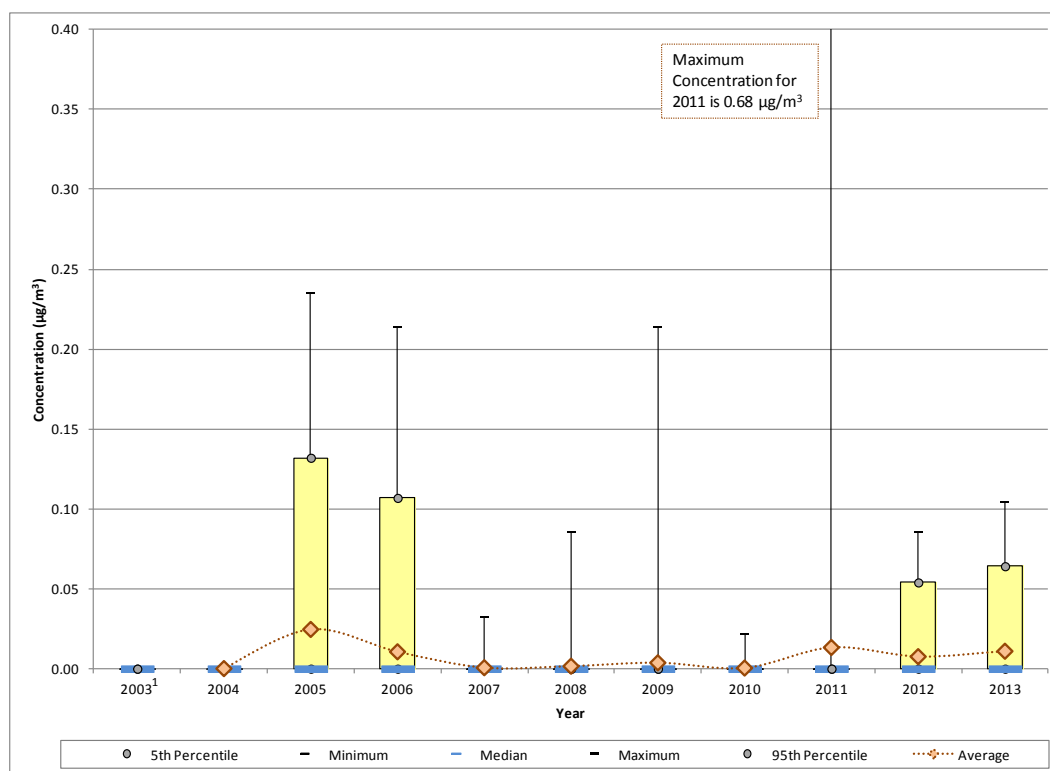


¹ A 1-year average is not presented because consistent sampling did not begin until March 2005.

Observations from Figure 12-39 for formaldehyde measurements collected at SPIL include the following:

- The maximum formaldehyde concentration ($162 \mu\text{g}/\text{m}^3$) was measured at SPIL on May 29, 2006 and is more than 10 times the maximum concentration for any of the other years shown in Figure 12-39 other than 2005. Of the 29 formaldehyde concentrations greater than $15 \mu\text{g}/\text{m}^3$, 12 were measured at SPIL in 2005, 17 were measured in 2006, and none were measured in the years that followed.
- The 1-year average concentration for 2006 is $13.76 \mu\text{g}/\text{m}^3$. After 2006, the 1-year average concentration decreased each year, reaching a minimum of $1.85 \mu\text{g}/\text{m}^3$ for 2009. Although difficult to discern in Figure 12-39, there is an increasing trend in the 1-year average concentration between 2009 and 2011, after which little change is shown.
- The majority of formaldehyde concentrations measured at SPIL fell within roughly the same range between 2011 and 2013, as indicated by the 5th and 95th percentiles.

Figure 12-40. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at SPIL

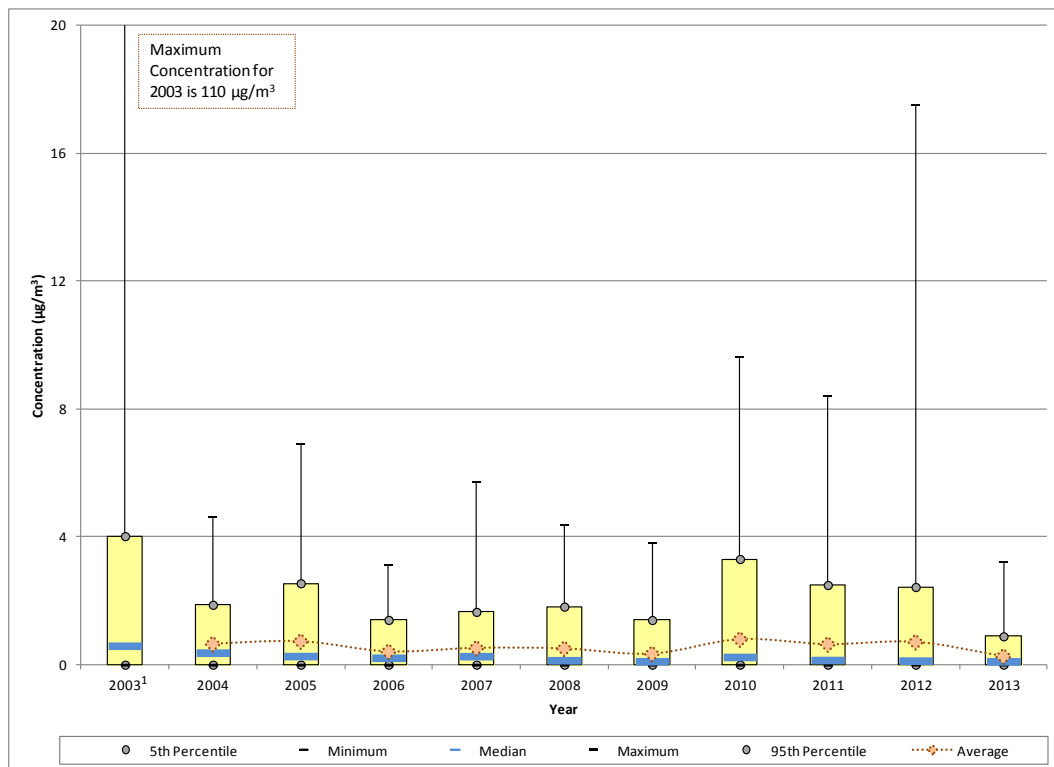


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 12-40 for hexachloro-1,3-butadiene measurements collected at SPIL include the following:

- The trends graph for hexachloro-1,3-butadiene measurements resembles the trends graph for 1,2-dichloroethane in that the statistical parameters reflect that non-detects make up the majority of measurements of this pollutant.
- There were no measured detections of hexachloro-1,3-butadiene measured at SPIL during the first 2 years of sampling. Non-detects made up 83 percent of measurements in 2005 and 93 percent in 2006. Between 2007 and 2010, the percentage of non-detects was constant at 98 percent. After 2010, the percentage of non-detects began to fall slightly each year, returning to 83 percent by 2013.
- The maximum hexachloro-1,3-butadiene concentration measured at SPIL was measured on December 11, 2011 ($0.68 \mu\text{g}/\text{m}^3$) and is the only measurement of this pollutant greater than $0.25 \mu\text{g}/\text{m}^3$. Only 39 total measured detections have been measured at SPIL since the onset of sampling. The effect of the non-detects (zeros) factored into the statistical calculations can be seen in the scale of the trends graph and by noting that none of the 1-year average concentrations shown are greater than $0.025 \mu\text{g}/\text{m}^3$.

Figure 12-41. Yearly Statistical Metrics for Trichloroethylene Concentrations Measured at SPIL



¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 12-41 for trichloroethylene measurements collected at SPIL include the following:

- The minimum and 5th percentile are both zero for all years of sampling, indicating that at least 5 percent of the measurements were non-detects for each year since sampling began at SPIL. The percentage of non-detects has ranged from 14 percent (2007) to 39 percent (2004).
- The maximum concentration of trichloroethylene ($110 \mu\text{g}/\text{m}^3$) was measured at SPIL in 2003 and is an order of magnitude greater than the next highest concentration ($17.5 \mu\text{g}/\text{m}^3$), which was measured in 2012. No other trichloroethylene concentrations greater than $10 \mu\text{g}/\text{m}^3$ have been measured at SPIL.
- The concentrations of trichloroethylene exhibit considerable variability, as indicated by confidence intervals calculated for the 1-year average concentrations, particularly for 2012, when the maximum concentration was nearly four times the next highest concentration measured that year and non-detects made up more than a quarter of the measurements.
- The 1-year average concentrations have fluctuated between $0.26 \mu\text{g}/\text{m}^3$ (2013) to $0.79 \mu\text{g}/\text{m}^3$ (2010), with no distinct trend in the concentrations. It should be noted however, that the difference between the 5th and 95th percentiles is at a minimum for

2013, indicating that most of the trichloroethylene measurements collected in 2013 at SPIL fell within a tighter range.

12.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at each Illinois monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

12.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Illinois sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 12-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 12-6. Risk Approximations for the Illinois Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Northbrook, Illinois - NBIL						
Acetaldehyde	0.0000022	0.009	62/62	2.37 ± 0.31	5.20	0.26
Benzene	0.0000078	0.03	61/61	0.47 ± 0.05	3.68	0.02
1,3-Butadiene	0.00003	0.002	38/61	0.03 ± 0.01	0.88	0.01
Carbon Tetrachloride	0.000006	0.1	61/61	0.60 ± 0.02	3.59	0.01
1,2-Dichloroethane	0.000026	2.4	53/61	0.06 ± 0.01	1.62	<0.01
Formaldehyde	0.000013	0.0098	62/62	1.98 ± 0.26	25.68	0.20
Acenaphthene ^a	0.000088	--	58/58	25.12 ± 8.19	2.21	--
Arsenic (PM ₁₀) ^a	0.0043	0.000015	59/59	0.62 ± 0.11	2.66	0.04
Fluoranthene ^a	0.000088	--	58/58	7.47 ± 2.52	0.66	--
Fluorene ^a	0.000088	--	57/58	19.24 ± 6.19	1.69	--
Naphthalene ^a	0.000034	0.003	58/58	155.94 ± 44.27	5.30	0.05
Schiller Park, Illinois - SPIL						
Acetaldehyde	0.0000022	0.009	61/61	2.37 ± 0.55	5.21	0.26
Benzene	0.0000078	0.03	60/60	0.74 ± 0.08	5.78	0.02
1,3-Butadiene	0.00003	0.002	59/60	0.13 ± 0.02	3.80	0.06
Carbon Tetrachloride	0.000006	0.1	60/60	0.64 ± 0.02	3.85	0.01
1,2-Dichloroethane	0.000026	2.4	57/60	0.08 ± 0.01	2.13	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.31 ± 0.49	43.00	0.34
Hexachloro-1,3-butadiene	0.000022	0.09	10/60	0.01 ± 0.01	0.24	<0.01
Trichloroethylene	0.0000048	0.002	44/60	0.26 ± 0.13	1.26	0.13

-- = a Cancer URE or Noncancer RfC is not available.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m³ for ease of viewing.

Table 12-6. Risk Approximations for the Illinois Monitoring Sites (Continued)

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Roxana, Illinois - ROIL						
Acetaldehyde	0.0000022	0.009	61/61	1.84 ± 0.22	4.05	0.20
Benzene	0.0000078	0.03	60/60	0.97 ± 0.11	7.54	0.03
1,3-Butadiene	0.00003	0.002	54/60	0.06 ± 0.01	1.71	0.03
Carbon Tetrachloride	0.000006	0.1	60/60	0.66 ± 0.02	3.94	0.01
1,2-Dichloroethane	0.000026	2.4	45/60	0.07 ± 0.01	1.93	<0.01
Ethylbenzene	0.0000025	1	60/60	0.31 ± 0.04	0.76	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.19 ± 0.57	41.43	0.33
Hexachloro-1,3-butadiene	0.000022	0.09	15/60	0.02 ± 0.01	0.45	<0.01

-- = a Cancer URE or Noncancer RfC is not available.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

Observations for the Illinois sites from Table 12-6 include the following:

- Formaldehyde and acetaldehyde are the pollutants with the highest annual average concentrations for all three sites.
- Formaldehyde has the highest cancer risk approximation for all three sites, ranging from 25.68 in-a-million for NBIL to 43.00 in-a-million for SPIL. There were no other pollutants for which a cancer risk approximation greater than 10 in-a-million was calculated.
- None of the pollutants of interest for NBIL, SPIL, or ROIL have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation among the pollutants of interest for the Illinois sites is formaldehyde (0.34 for SPIL).

12.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 12-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 12-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 12-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each Illinois site, as presented in Table 12-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 12-7. Table 12-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 12.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 12-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Illinois Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Northbrook, Illinois (Cook County) - NBIL					
Benzene	1,391.32	Formaldehyde	1.48E-02	Formaldehyde	25.68
Formaldehyde	1,135.39	Benzene	1.09E-02	Naphthalene	5.30
Ethylbenzene	756.81	1,3-Butadiene	6.47E-03	Acetaldehyde	5.20
Acetaldehyde	623.34	Hexavalent Chromium	4.02E-03	Benzene	3.68
1,3-Butadiene	215.66	Naphthalene	3.60E-03	Carbon Tetrachloride	3.59
Tetrachloroethylene	187.87	Arsenic, PM	2.64E-03	Arsenic	2.66
Naphthalene	105.84	Ethylbenzene	1.89E-03	Acenaphthene	2.21
Trichloroethylene	99.56	POM, Group 2b	1.81E-03	Fluorene	1.69
Dichloromethane	35.41	Acetaldehyde	1.37E-03	1,2-Dichloroethane	1.62
POM, Group 2b	20.53	POM, Group 2d	1.19E-03	1,3-Butadiene	0.88
Schiller Park, Illinois (Cook County) - SPIL					
Benzene	1,391.32	Formaldehyde	1.48E-02	Formaldehyde	43.00
Formaldehyde	1,135.39	Benzene	1.09E-02	Benzene	5.78
Ethylbenzene	756.81	1,3-Butadiene	6.47E-03	Acetaldehyde	5.21
Acetaldehyde	623.34	Hexavalent Chromium	4.02E-03	Carbon Tetrachloride	3.85
1,3-Butadiene	215.66	Naphthalene	3.60E-03	1,3-Butadiene	3.80
Tetrachloroethylene	187.87	Arsenic, PM	2.64E-03	1,2-Dichloroethane	2.13
Naphthalene	105.84	Ethylbenzene	1.89E-03	Trichloroethylene	1.26
Trichloroethylene	99.56	POM, Group 2b	1.81E-03	Hexachloro-1,3-butadiene	0.24
Dichloromethane	35.41	Acetaldehyde	1.37E-03		
POM, Group 2b	20.53	POM, Group 2d	1.19E-03		

Table 12-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Illinois Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Roxana, Illinois (Madison County) - ROIL					
Formaldehyde	117.39	Coke Oven Emissions, PM	1.58E-02	Formaldehyde	41.43
Benzene	116.81	Formaldehyde	1.53E-03	Benzene	7.54
Ethylbenzene	56.77	Hexavalent Chromium	1.29E-03	Acetaldehyde	4.05
Acetaldehyde	50.30	Arsenic, PM	1.03E-03	Carbon Tetrachloride	3.94
Coke Oven Emissions, PM	15.95	Benzene	9.11E-04	1,2-Dichloroethane	1.93
Naphthalene	14.00	Naphthalene	4.76E-04	1,3-Butadiene	1.71
1,3-Butadiene	12.69	1,3-Butadiene	3.81E-04	Ethylbenzene	0.76
Dichloromethane	12.11	Nickel, PM	3.20E-04	Hexachloro-1,3-butadiene	0.45
Tetrachloroethylene	3.60	POM, Group 5a	2.42E-04		
POM, Group 2b	1.85	POM, Group 2b	1.63E-04		

Table 12-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Illinois Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Northbrook, Illinois (Cook County) - NBIL					
Toluene	10,461.60	Acrolein	4,043,182.36	Acetaldehyde	0.26
Xylenes	3,369.01	Formaldehyde	115,856.06	Formaldehyde	0.20
Methanol	3,041.83	1,3-Butadiene	107,829.46	Naphthalene	0.05
Hexane	2,784.74	Cyanide Compounds, gas	86,974.16	Arsenic	0.04
Benzene	1,391.32	Acetaldehyde	69,259.50	Benzene	0.02
Formaldehyde	1,135.39	Trichloroethylene	49,780.32	1,3-Butadiene	0.01
Ethylene glycol	1,052.17	Benzene	46,377.32	Carbon Tetrachloride	0.01
Ethylbenzene	756.81	Arsenic, PM	40,902.71	1,2-Dichloroethane	<0.01
Acetaldehyde	623.34	Naphthalene	35,279.80		
Methyl isobutyl ketone	342.65	Xylenes	33,690.12		
Schiller Park, Illinois (Cook County) - SPIL					
Toluene	10,461.60	Acrolein	4,043,182.36	Formaldehyde	0.34
Xylenes	3,369.01	Formaldehyde	115,856.06	Acetaldehyde	0.26
Methanol	3,041.83	1,3-Butadiene	107,829.46	Trichloroethylene	0.13
Hexane	2,784.74	Cyanide Compounds, gas	86,974.16	1,3-Butadiene	0.06
Benzene	1,391.32	Acetaldehyde	69,259.50	Benzene	0.02
Formaldehyde	1,135.39	Trichloroethylene	49,780.32	Carbon Tetrachloride	0.01
Ethylene glycol	1,052.17	Benzene	46,377.32	Hexachloro-1,3-butadiene	<0.01
Ethylbenzene	756.81	Arsenic, PM	40,902.71	1,2-Dichloroethane	<0.01
Acetaldehyde	623.34	Naphthalene	35,279.80		
Methyl isobutyl ketone	342.65	Xylenes	33,690.12		

Table 12-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Illinois Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Roxana, Illinois (Madison County) – ROIL					
Toluene	635.77	Acrolein	274,415.42	Formaldehyde	0.33
Xylenes	208.66	Chlorine	95,420.68	Acetaldehyde	0.20
Hexane	195.81	Hexamethylene-1,6-diisocyanate, gas	25,000.00	Benzene	0.03
Methanol	178.11	Manganese, PM	16,632.19	1,3-Butadiene	0.03
Hydrochloric acid	128.20	Arsenic, PM	16,022.05	Carbon Tetrachloride	0.01
Formaldehyde	117.39	Lead, PM	14,477.27	Ethylbenzene	<0.01
Benzene	116.81	Formaldehyde	11,978.64	Hexachloro-1,3-butadiene	<0.01
Ethylbenzene	56.77	Cyanide Compounds, gas	7,490.07	1,2-Dichloroethane	<0.01
Ethylene glycol	53.93	Nickel, PM	7,414.81		
Acetaldehyde	50.30	Hydrochloric acid	6,410.24		

Observations from Table 12-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Cook County. These same pollutants are the highest emitted pollutants with cancer UREs in Madison County, although the order differs. The quantity of emissions is considerably different between the two counties, with the emissions for Cook County an order of magnitude greater than Madison County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Cook County are formaldehyde, benzene, and 1,3-butadiene. Coke oven emissions top Madison County's toxicity-weighted emissions, followed by formaldehyde and hexavalent chromium.
- Seven of the highest emitted pollutants in Cook County also have the highest toxicity-weighted emissions while six of the highest emitted pollutants in Madison County also have the highest toxicity-weighted emissions.
- For NBIL and SPIL, formaldehyde is the pollutant with the highest cancer risk approximation. This pollutant also has the highest toxicity-weighted emissions and ranks second for quantity emitted. Benzene, acetaldehyde, and 1,3-butadiene also appear on all three lists for both sites. For ROIL, formaldehyde is also the pollutant with the highest cancer risk approximation. This pollutant also has the highest emissions in Madison County and the second highest toxicity-weighted emissions. Benzene and 1,3-butadiene also appear on all three lists for ROIL.
- Carbon tetrachloride, which has the fifth highest cancer risk approximation for NBIL and fourth highest cancer risk approximation for SPIL and ROIL, does not appear on either county's emissions-based list. Similarly, 1,2-dichloroethane appears on neither emissions-based list though it ranks among the pollutants with the highest cancer risk approximations for all three sites.
- Naphthalene has the second highest cancer risk approximation for NBIL. This pollutant also has the fifth highest toxicity-weighted emissions for Cook County and ranks seventh for quantity emitted. POM, Group 2b ranks 10th for quantity emitted and eighth for toxicity-weighted emissions in Cook County. POM, Group 2b includes acenaphthene, fluorene, and fluoranthene, all three of which are pollutants of interest for NBIL.
- Trichloroethylene has the seventh highest cancer risk approximation for SPIL and is the eighth highest emitted pollutant in Cook County, but does not appear among the pollutants with the highest toxicity-weighted emissions (this pollutant ranks 13th).
- Arsenic has the sixth highest cancer risk approximation for NBIL (SPIL did not sample metals). Arsenic ranks sixth for Cook County for its toxicity-weighted emissions, but does not appear among the highest emitted pollutants (this pollutant ranks 17th).

- NBIL is one of two NMP sites that sampled pollutants from all six methods. At least one pollutant from each of the six methods appears among the pollutants with the highest toxicity-weighted emissions.
- While seven of the 10 highest emitted pollutants in Madison County are sampled for at ROIL, only three of the pollutants with the highest toxicity-weighted emissions are sampled for at ROIL.

Observations from Table 12-8 include the following:

- Toluene and xylenes are the highest emitted pollutants with noncancer RfCs in both Cook and Madison Counties, although the quantity emitted is significantly higher in Cook County.
- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties is acrolein. Although acrolein was sampled for at all three sites, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.
- Only four of the highest emitted pollutants also have the highest toxicity-weighted emissions for Cook County (formaldehyde, benzene, xylenes, and acetaldehyde). The highest emitted pollutants and the pollutants with the highest toxicity-weighted emissions for Madison County have only two pollutants in common (formaldehyde and hydrochloric acid). This speaks to the relative toxicity of a pollutant; a pollutant does not have to be emitted in high quantities to be hazardous to human health.
- Formaldehyde and acetaldehyde have the highest noncancer hazard approximations for all three Illinois monitoring sites (albeit less than an HQ of 1.0). These two pollutants appear on both emissions-based lists for Cook County but only formaldehyde appears on both lists for Madison County (acetaldehyde ranks 12th for its toxicity-weighted emissions).
- Naphthalene, arsenic, benzene, and 1,3-butadiene are pollutants of interest for NBIL and are among those with the highest toxicity-weighted emissions in Cook County but are not among the highest emitted. Trichloroethylene, benzene, and 1,3-butadiene are pollutants of interest for SPIL and are among those with the highest toxicity-weighted emissions but are not among the highest emitted in Cook County.
- While six of the 10 highest emitted pollutants in Madison County (with noncancer RfCs) are sampled for at ROIL, only two of the pollutants with the highest toxicity-weighted emissions are sampled for at ROIL. Several metals appear among the pollutants with the highest toxicity-weighted emissions in Madison County, although none are among the highest emitted. Metals were not sampled for at ROIL under the NMP.

12.6 Summary of the 2013 Monitoring Data for NBIL, SPIL, and ROIL

Results from several of the data treatments described in this section include the following:

- ❖ *Twenty pollutants (two carbonyl compounds, 12 VOCs, four PAHs, one speciated metal, and hexavalent chromium) failed screens for NBIL; 12 pollutants (three carbonyl compounds and nine VOCs) failed screens for SPIL; and 11 pollutants (three carbonyl compounds and eight VOCs) failed screens for ROIL.*
- ❖ *Formaldehyde had the highest annual average concentration among the pollutants of interest for SPIL and ROIL, while acetaldehyde had the highest annual average concentration among the pollutants of interest for NBIL. None of the other site-specific pollutants of interest had annual average concentrations greater than 1 $\mu\text{g}/\text{m}^3$.*
- ❖ *The maximum concentrations of several pollutants across the program were measured at the Chicago sites. The maximum concentrations of acetaldehyde and trichloroethylene program-wide were measured at SPIL. The maximum concentrations of acenaphthene, fluorene, and naphthalene program-wide were measured at NBIL.*
- ❖ *Concentrations of acetaldehyde have been increasing significantly in recent years at NBIL. Several of NBIL's pollutants of interest, including benzene, 1,3-butadiene, arsenic, and formaldehyde, exhibited less variability in 2013, as measurements fell within their smallest range. Like many NMP sites, a significant decrease in the number of non-detects reported for 1,2-dichloroethane has occurred at both Chicago sites. While no longer increasing, some of the highest acetaldehyde measurements have been measured at SPIL in recent years.*
- ❖ *Formaldehyde has the highest cancer risk approximation among the pollutants of interest for all three sites. None of the pollutants of interest have noncancer hazard approximations greater than an HQ of 1.0.*

13.0 Sites in Indiana

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP sites in Indiana, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

13.1 Site Characterization

This section characterizes the Indiana monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

One Indiana monitoring site (INDEM) is located in the Chicago-Naperville-Elgin, IL-IN-WI CBSA, and another site (WPIN) is located in the Indianapolis-Carmel-Anderson, IN CBSA. Figures 13-1 and 13-3 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites and their immediate surroundings. Figures 13-2 and 13-4 identify nearby point source emissions locations by source category near INDEM and WPIN, respectively, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figures 13-2 and 13-4. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile boundary are still visible on each map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 13-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 13-1. Gary, Indiana (INDEM) Monitoring Site

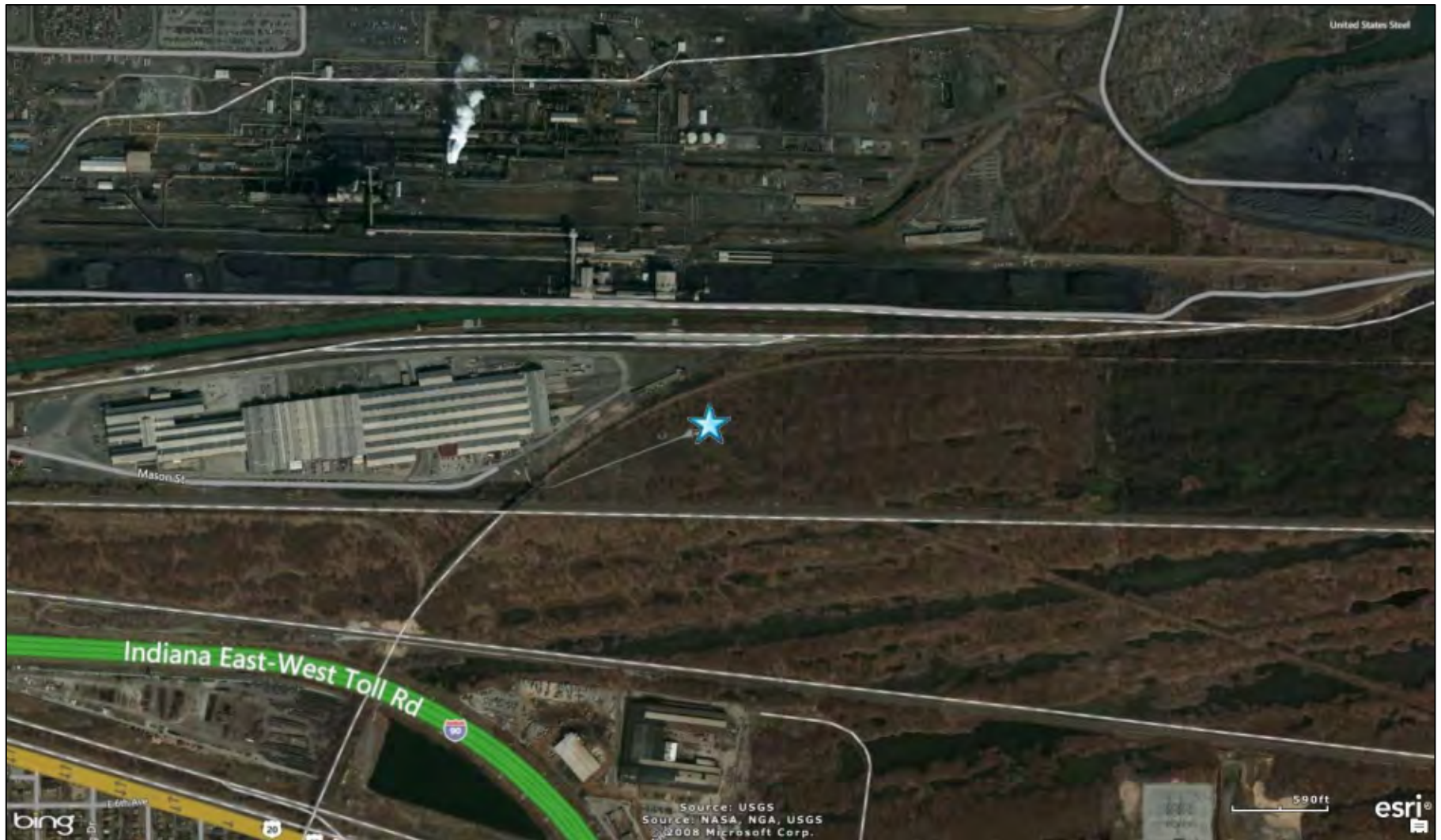


Figure 13-2. NEI Point Sources Located Within 10 Miles of INDEM

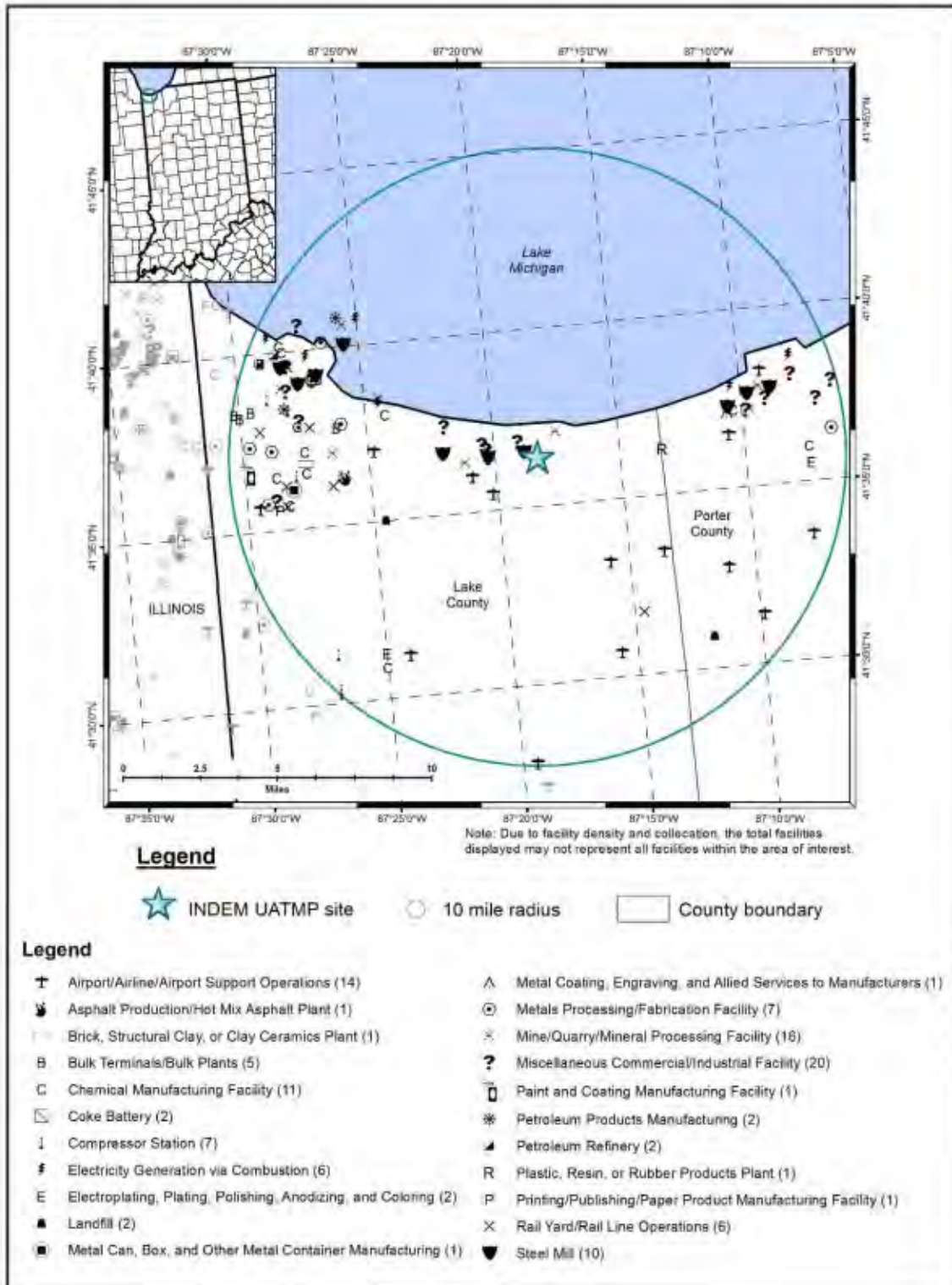


Figure 13-3. Indianapolis, Indiana (WPIN) Monitoring Site

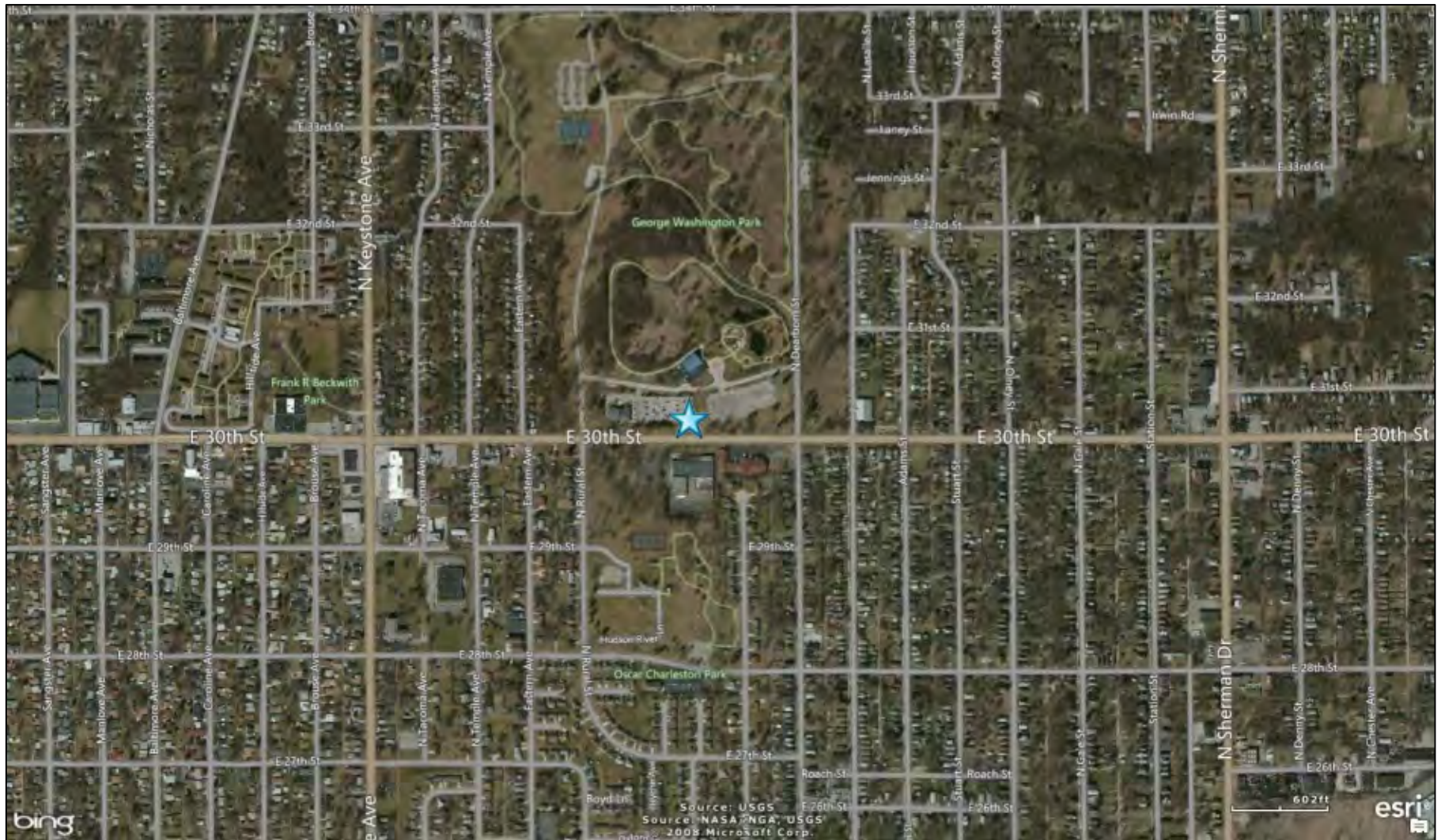


Figure 13-4. NEI Point Sources Located Within 10 Miles of WPIN

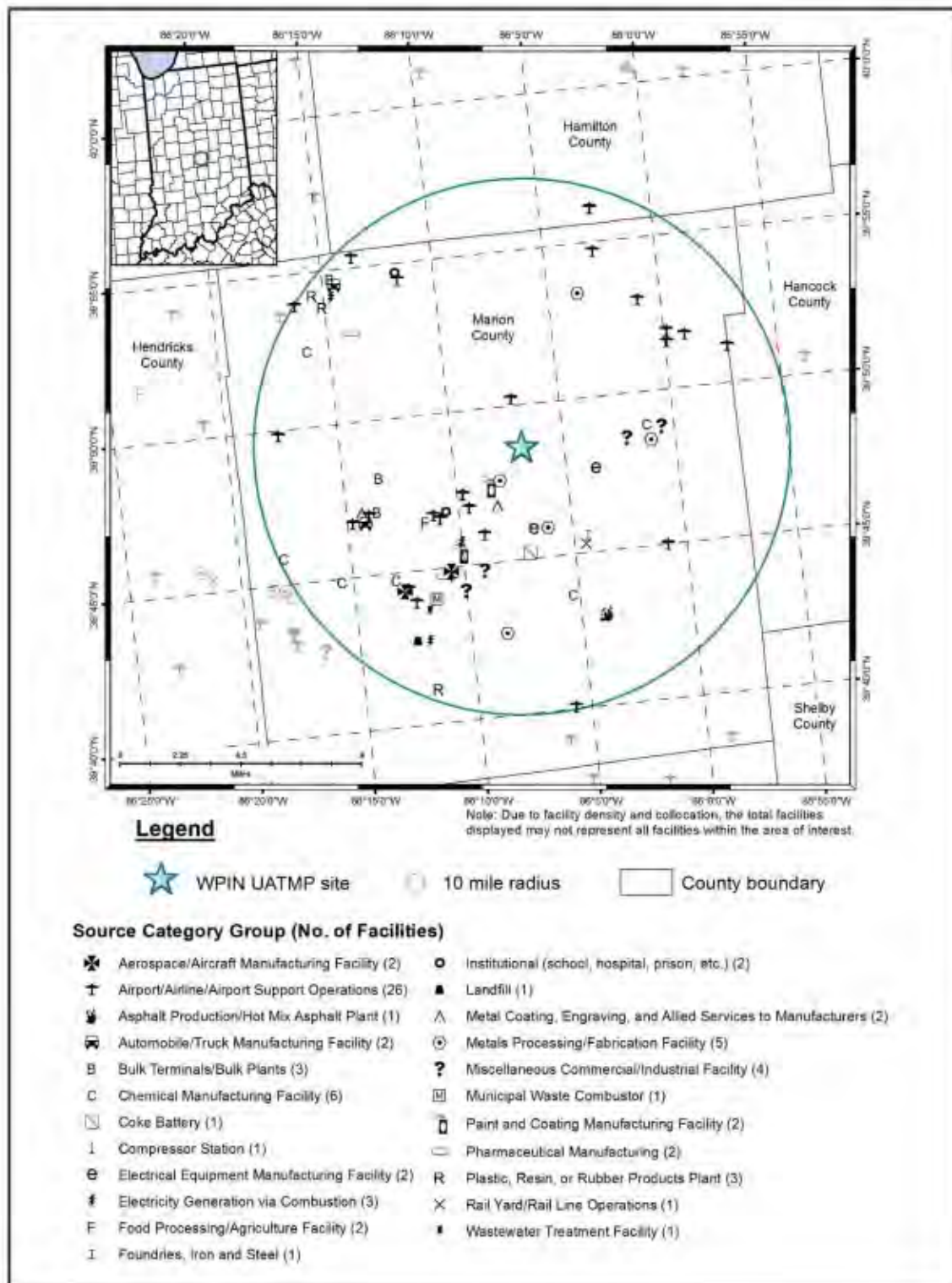


Table 13-1. Geographical Information for the Indiana Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
INDEM	18-089-0022	Gary	Lake	Chicago-Naperville-Elgin, IL-IN-WI	41.606680, -87.304729	Industrial	Urban/City Center	Black carbon, VOCs, SO ₂ , NO, NO ₂ , NO _x , PAMS, O ₃ , Meteorological parameters, PM ₁₀ , PM _{2.5} , PM _{2.5} Speciation, SNMOC, IMPROVE Speciation.
WPIN	18-097-0078	Indianapolis	Marion	Indianapolis-Carmel-Anderson, IN	39.811097, -86.114469	Residential	Suburban	Black carbon, TSP Metals, CO, VOCs, SNMOCs, SO ₂ , NO _y , NO _x , NO ₂ , NO, O ₃ , Meteorological parameters, PM ₁₀ , PM _{2.5} , PM _{2.5} Speciation, PM Coarse, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

INDEM is located in Gary, Indiana, roughly 11 miles east of the Indiana-Illinois border and 25 miles southeast of Chicago. Gary is located on the southernmost bank of Lake Michigan. The site is located just north of I-90, the edge of which can be seen in the bottom left portion of Figure 13-1, and I-65. Although INDEM resides on the Indiana Dunes National Lakeshore, about 1 mile south of the Lake Michigan shoreline, the surrounding area is highly industrialized, as shown in Figure 13-1, and several railroads transverse the area. Figure 13-2 shows that the majority of point sources within 10 miles of INDEM are located to the west of the site. There is also a second cluster of facilities located to the east of INDEM in Porter County. The emissions source categories with the highest number of sources within 10 miles of INDEM include steel mills; aircraft operations, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or TV stations; chemical manufacturing; and mine/quarry/mineral processing. The sources closest to INDEM include a steel mill; an industrial complex that includes several facilities that fall into the miscellaneous commercial/industrial category as well as two mines/quarries and another steel mill; and a heliport at a police station and a hospital.

WPIN is located in the parking lot of a police station across from George Washington Park, near East 30th Street in northeast Indianapolis. Figure 13-3 shows that the area surrounding WPIN is suburban and residential, with little industry in close proximity. A church and a charitable organization are located across the street from Washington Park, as is Oscar Charleston Park. Figure 13-4 shows that the majority of point sources are located to the south and southwest of WPIN, towards the center of Marion County. The source category with the highest number of sources near WPIN is the airport operations source category. The sources closest to WPIN are a painting and coating manufacturer, a metals processing/fabrication facility, and a heliport. Each of these facilities is located within 2 miles of WPIN.

Table 13-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Indiana monitoring sites. Table 13-2 includes both county-level population and vehicle registration information. Table 13-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 13-2 presents the county-level daily VMT for Marion and Lake Counties.

Table 13-2. Population, Motor Vehicle, and Traffic Information for the Indiana Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
INDEM	Lake	491,456	425,854	34,754	I-90 N of I-65 Interchange	15,741,000
WPIN	Marion	928,281	830,851	143,970	I-70 b/w Exit 85 & 87	31,727,000

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect 2013 data (IN BMV, 2014)

³AADT reflects 2011 data (IN DOT, 2011)

⁴County-level VMT reflects 2013 data (IN DOT, 2013)

Observations from Table 13-2 include the following:

- Marion County has almost twice the county-level population and vehicle registration as Lake County.
- The county-level population for Marion County rounds out the top third among county-level populations for other NMP sites, while the population for Lake County is in the middle of the range. The county-level vehicle registrations mimic these rankings.
- WPIN experiences a significantly higher traffic volume than INDEM. The traffic estimate for WPIN is based on data from I-70 between exits 85 and 87. Interstate-70 is just less than 1 mile south of WPIN. Traffic data were not available for a location closer to WPIN. The traffic volume near WPIN is the seventh highest among NMP sites.
- The traffic volume for INDEM is based on data from the I-90 toll road north of the I-65 interchange. Traffic near INDEM is in the middle of the range among traffic volumes for NMP sites.
- The VMT for Marion County is roughly twice the VMT for Lake County. The Marion County VMT ranks 11th among counties with NMP sites, while the VMT for Lake County is in the middle of the range, ranking 21st.

13.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Indiana on sample days, as well as over the course of the year.

13.2.1 Climate Summary

The city of Gary is located to the southeast of Chicago, at the southern-most tip of Lake Michigan. Climate of the region is characterized by warm, humid summers, cloudy and cold

winters, and frequently changing weather as storm systems regularly track across the region. Gary's proximity to Lake Michigan is an important factor controlling the weather of the area. In the summer, warm temperatures can be suppressed, while cold winter temperatures are often moderated. Winds that blow across Lake Michigan and over Gary in late fall and winter can provide cloudiness and abundant amounts of lake-effect snow while lake breezes can bring relief from summer heat (Wood, 2004; ISCO, 2002).

The city of Indianapolis is located in the center of Indiana, and experiences a temperate continental climate and frequently changing weather patterns. Summers are warm and humid, as moist air flows northward out of the Gulf of Mexico. Winters are chilly with occasional Arctic outbreaks. Precipitation is spread rather evenly throughout the year, with much of the spring and summer precipitation resulting from showers and thunderstorms. Annual snowfall totals average around 30 inches, with winters receiving less than 10 inches being uncommon. The prevailing wind direction is southwesterly (Wood, 2004; ISCO, 2002).

13.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the Indiana monitoring sites (NCDC, 2013), as described in Section 3.4.2. The two closest weather stations are located at Lansing Municipal Airport (near INDEM) and Eagle Creek Airpark (near WPIN), WBAN 04879 and 53842, respectively. Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 13-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 13-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 13-3 is the 95 percent confidence interval for each parameter. As shown in Table 13-3, average meteorological conditions on sample days at WPIN and INDEM were representative of average weather conditions experienced throughout the year near these locations.

Table 13-3. Average Meteorological Conditions near the Indiana Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Gary, Indiana - INDEM									
Lansing Municipal Airport 04879 (41.54, -87.53)	12.7 miles	Sample Days (61)	56.8 ± 5.6	48.6 ± 5.3	38.8 ± 5.3	44.1 ± 4.9	71.6 ± 3.0	NA	6.7 ± 0.7
	249° (WSW)	2013	57.6 ± 2.2	49.2 ± 2.0	39.2 ± 1.9	44.5 ± 1.8	71.2 ± 1.1	NA	7.0 ± 0.3
Indianapolis, Indiana - WPIN									
Eagle Creek Airpark 53842 (39.83, -86.30)	9.7 miles	Sample Days (65)	59.4 ± 5.4	51.6 ± 5.1	42.3 ± 5.2	47.1 ± 4.8	73.0 ± 2.9	1018.2 ± 1.8	5.5 ± 0.5
	276° (W)	2013	59.8 ± 2.1	51.7 ± 2.0	42.3 ± 2.0	47.2 ± 1.8	72.4 ± 1.1	1017.7 ± 0.7	5.7 ± 0.3

¹Sample day averages are shaded in orange help differentiate the sample day averages from the full-year averages.

NA= Sea level pressure was not recorded at the Lansing Municipal Airport.

13.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations nearest the Indiana sites, as presented in Section 13.2.2, were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

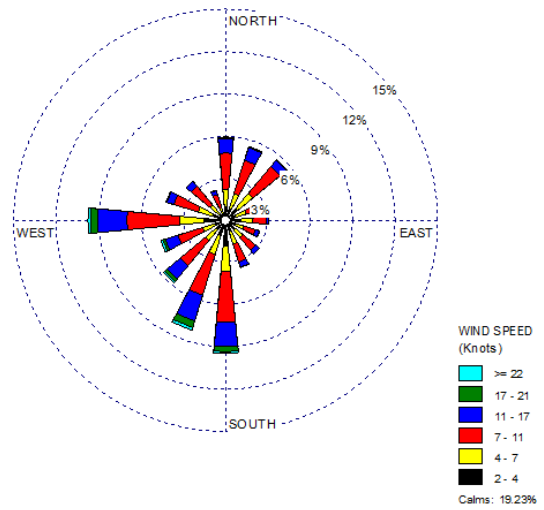
Figure 13-5 presents a map showing the distance between the weather station and INDEM, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 13-5 also presents three different wind roses for the INDEM monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 13-6 presents the distance map and three wind roses for WPIN.

Figure 13-5. Wind Roses for the Lansing Municipal Airport Weather Station near INDEM

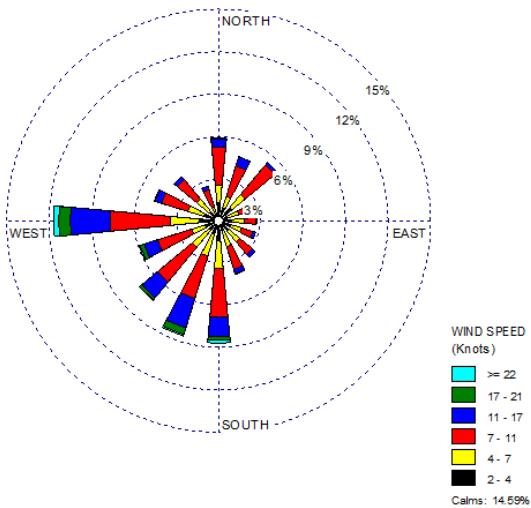
Location of INDEM and Weather Station



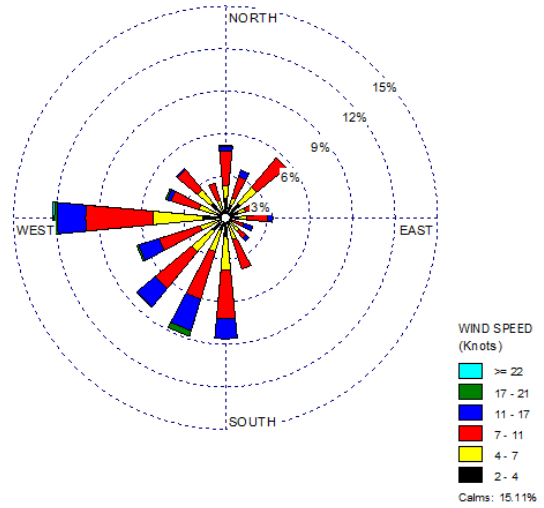
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 13-5 for INDEM include the following:

- The weather station at Lansing Municipal Airport is the closest weather station to INDEM, although it is located nearly 13 miles west-southwest of INDEM. The location of the weather station is just over the Illinois-Indiana state line and farther inland than INDEM and thus, farther away from the influences of Lake Michigan than INDEM.
- The historical wind rose for INDEM shows that winds from the south to south-southwest and west are the predominant wind directions over the 2003-2012 time frame. Northerly to northeasterly winds off Lake Michigan account for less than 20 percent of the wind measurements, as do calm winds (those less than or equal to 2 knots). Winds from the southeast and northwest quadrants were less frequently observed. The strongest winds were those from the south to southwest to west.
- The wind patterns shown on the 2013 wind rose generally resemble the wind patterns shown on the historical wind rose. There were, however, fewer calm winds and a higher percentage of winds from the west in 2013.
- The sample day wind patterns resemble the full-year wind patterns, although there were fewer observations of northerly and north-northeasterly winds.

Observations from Figure 13-6 for WPIN include the following:

- The weather station at Eagle Creek Airpark is the closest weather station to WPIN and is located approximately 10 miles west of WPIN. Eagle Creek Airpark is located on the southeast edge of the Eagle Creek Reservoir.
- Winds from the south, from the western quadrants, and from the north account for the majority (nearly 55 percent) of wind observations from 2003 to 2012, while winds from the eastern quadrants were observed for approximately one-quarter of the observations. Calm winds were observed for roughly 19 percent of observations. The strongest winds tended to flow from the northwest.
- The wind patterns on the 2012 wind rose resemble the historical wind patterns, although winds from the western quadrants account for an even higher percentage of wind observations. The calm rate was slightly lower in 2013 (accounting for roughly 17 percent of observations).
- The sample day wind patterns resemble the full-year wind patterns but with a higher percentage of winds from the south to southwest and fewer calm wind observations.

13.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Indiana monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 13-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 13-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Carbonyl compounds were sampled for at both INDEM and WPIN.

Table 13-4. Risk-Based Screening Results for the Indiana Monitoring Sites

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Gary, Indiana - INDEM						
Formaldehyde	0.077	61	61	100.00	50.41	50.41
Acetaldehyde	0.45	60	61	98.36	49.59	100.00
Total		121	122	99.18		
Indianapolis, Indiana - WPIN						
Acetaldehyde	0.45	58	58	100.00	50.00	50.00
Formaldehyde	0.077	58	58	100.00	50.00	100.00
Total		116	116	100.00		

Observations from Table 13-4 include the following:

- Formaldehyde, acetaldehyde, and propionaldehyde are the only carbonyl compounds with risk screening values.
- Acetaldehyde and formaldehyde are the only pollutants to fail screens for INDEM and WPIN.
- Formaldehyde failed 100 percent of screens for both sites. Acetaldehyde failed 100 percent of screens for WPIN and 98 percent of screens for INDEM. Both pollutants were identified as pollutants of interest for each site.

13.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Indiana monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at the Indiana sites are provided in Appendix L.

13.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Indiana site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Indiana monitoring sites are presented in Table 13-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 13-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Indiana Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Gary, Indiana - INDEM						
Acetaldehyde	61/61	0.88 ± 0.11	1.16 ± 0.18	1.11 ± 0.26	1.02 ± 0.11	1.04 ± 0.09
Formaldehyde	61/61	1.47 ± 0.13	2.87 ± 0.98	2.77 ± 0.57	1.49 ± 0.19	2.14 ± 0.32
Indianapolis, Indiana - WPIN						
Acetaldehyde	58/58	1.53 ± 0.26	2.33 ± 0.31	1.83 ± 0.22	1.32 ± 0.19	1.78 ± 0.16
Formaldehyde	58/58	2.48 ± 0.33	4.64 ± 0.57	4.15 ± 0.63	2.05 ± 0.42	3.41 ± 0.37

Observations for the Indiana sites from Table 13-5 include the following:

- For both sites, acetaldehyde and formaldehyde were detected in all of the valid carbonyl compound samples collected.
- The annual average concentration of formaldehyde is greater than the annual average concentration of acetaldehyde for INDEM. The same is true for WPIN. In both cases, the acetaldehyde averages are roughly half the formaldehyde average.
- The annual average concentrations of acetaldehyde and formaldehyde are higher at WPIN than INDEM.
- The second and third quarter average concentrations of formaldehyde are significantly higher than the first and fourth quarter averages for INDEM. A review of the data shows that the 14 highest formaldehyde concentrations (those greater than $2.50 \mu\text{g}/\text{m}^3$) were measured between April and September and ranged from $2.69 \mu\text{g}/\text{m}^3$ to $8.90 \mu\text{g}/\text{m}^3$; conversely, all but two of the 22 lowest concentrations (those less than $1.50 \mu\text{g}/\text{m}^3$) were measured between January and March or October and December. This supports the trend identified in Section 4.4.2 indicating that formaldehyde concentrations tended to be higher during the warmer months of the year.
- This trend in seasonality continues at WPIN. All but one of the 20 formaldehyde concentrations greater than $4.0 \mu\text{g}/\text{m}^3$ were measured between April and September while all 11 measurements less than $2.00 \mu\text{g}/\text{m}^3$ were measured in February or between October and December.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Indiana sites from those tables include the following:

- WPIN's annual average concentration of formaldehyde is the sixth highest annual average of this pollutant among NMP sites sampling carbonyl compounds. WPIN does not appear in Table 4-10 for acetaldehyde (it ranks 13th).
- INDEM does not appear in Table 4-10. Its annual average concentration of formaldehyde ranks 19th and its annual average concentration of acetaldehyde ranks 24th among NMP sites sampling carbonyl compounds.

13.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 13-4 for INDEM and WPIN. Figures 13-7 and 13-8 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 13-7. Program vs. Site-Specific Average Acetaldehyde Concentrations

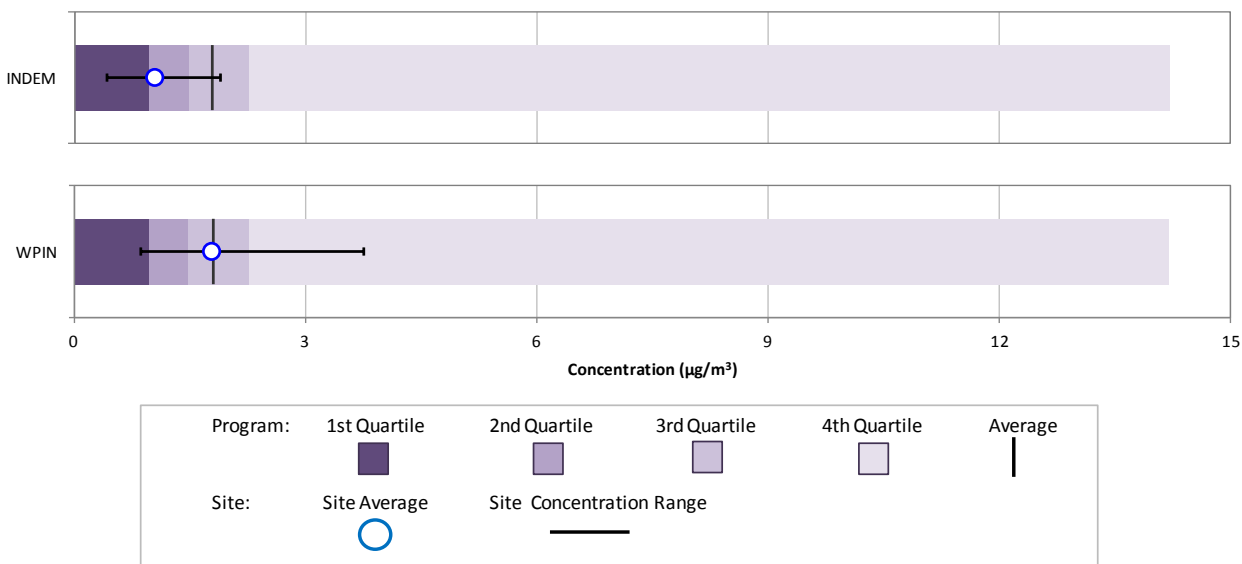
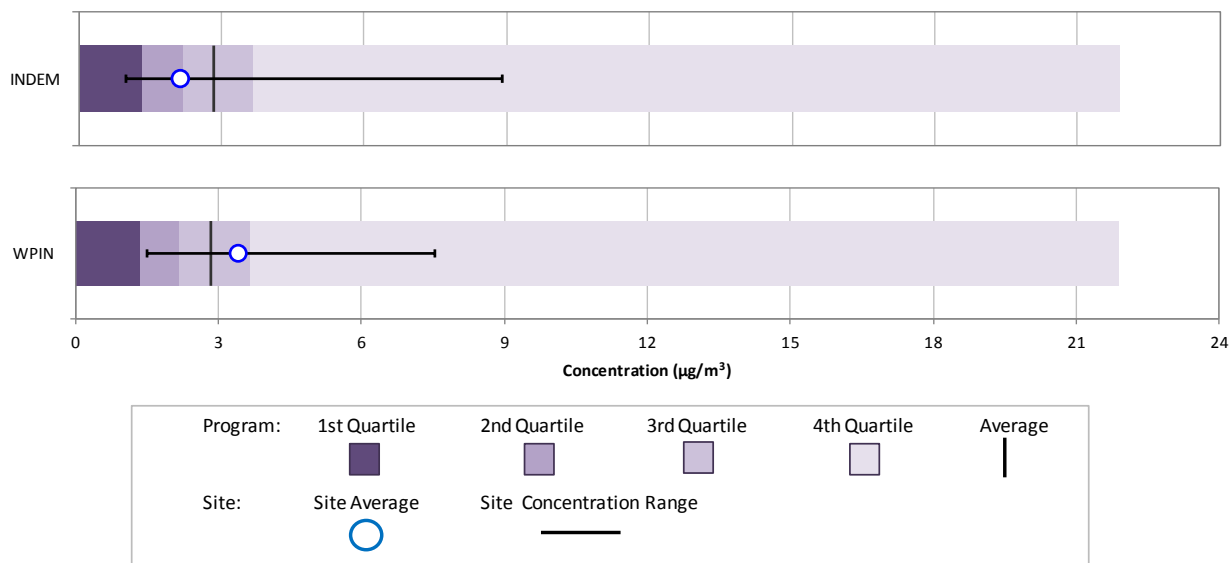


Figure 13-8. Program vs. Site-Specific Average Formaldehyde Concentrations



Observations from Figures 13-7 and 13-8 include the following:

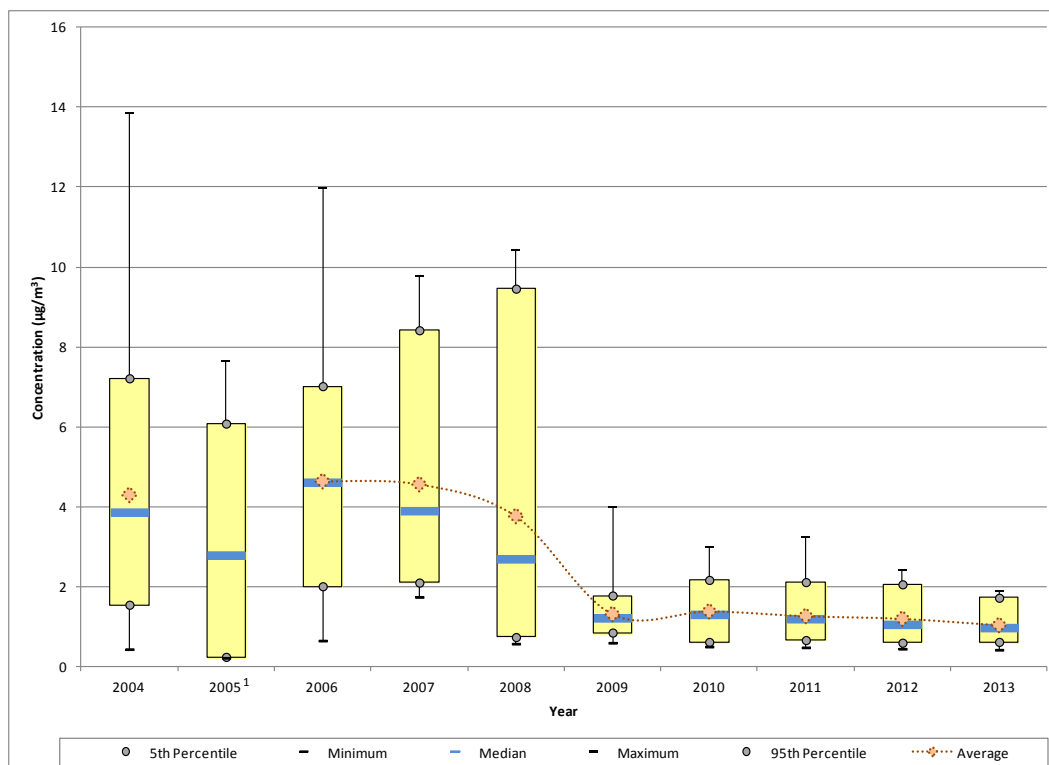
- Figure 13-7 presents the box plots for both sites for acetaldehyde. The annual average concentration for INDEM is less than both the program-level average and median concentrations. The maximum concentration of acetaldehyde measured at INDEM is just greater than the program-level average concentration as well as the annual average concentration for WPIN. WPIN's annual average concentration is similar to the program-level average concentration. The minimum concentration measured at WPIN is just less than the program-level first quartile.
- Figure 13-8 presents the box plots for formaldehyde for both sites. Although the range of formaldehyde concentrations measured at INDEM is larger than the range measured at WPIN, INDEM's annual average concentration is less than WPIN's. The annual average concentration for INDEM is less than the program-level average concentration and similar to the program-level median concentration while the annual average for WPIN is greater than the program-level average but less than the third quartile. The minimum formaldehyde concentration measured at WPIN is greater than the program-level first quartile.

13.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. INDEM and WPIN have sampled carbonyl compounds under the NMP since 2004 and 2007, respectively. Thus, Figures 13-9 through 13-12 present the 1-year statistical metrics for each of the pollutants of interest first for INDEM, then for WPIN. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a

minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 13-9. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at INDEM



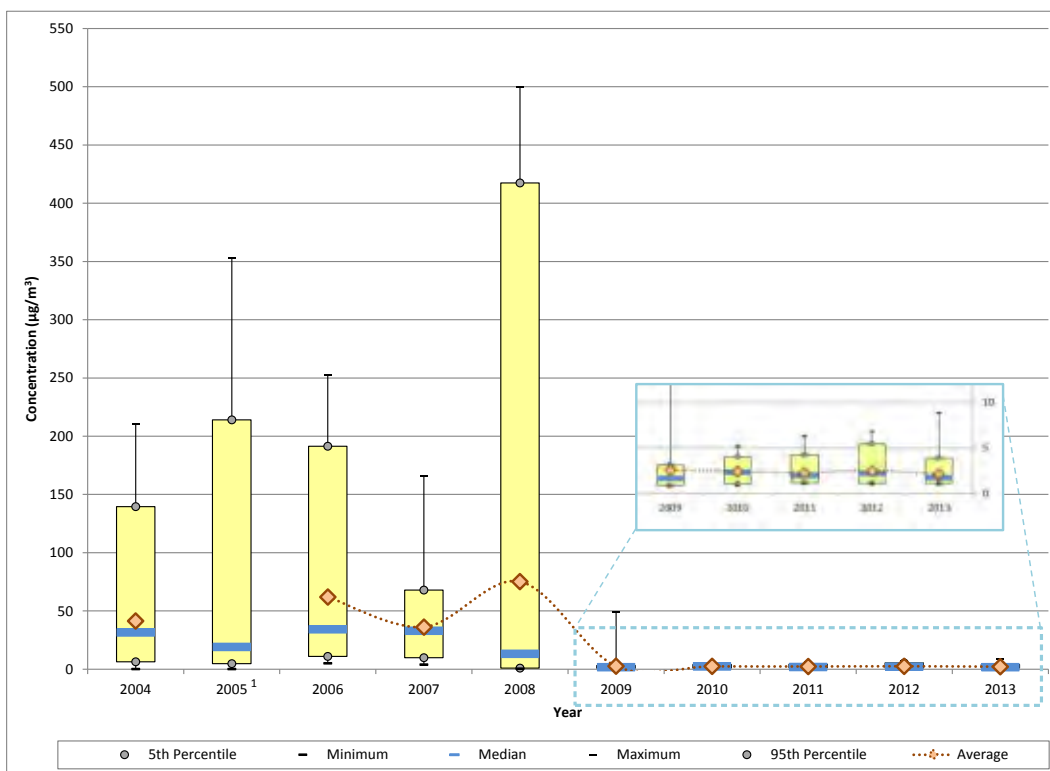
¹ A 1-year average is not presented due to a break in sampling between September 2005 and November 2005.

Observations from Figure 13-9 for acetaldehyde measurements collected at INDEM include the following:

- Although carbonyl compound sampling under the NMP began in 2003, samples were only collected for 3 months. Carbonyl compound sampling began in earnest at INDEM at the beginning of 2004; thus, Figure 13-9 begins with 2004. However, a 1-year average concentration is not presented for 2005 due to a break in sampling between September 2005 and November 2005, although the range of measurements is provided.
- The maximum acetaldehyde concentration shown ($13.8 \mu\text{g}/\text{m}^3$) was measured at INDEM on June 14, 2004. Four additional concentrations greater than $10 \mu\text{g}/\text{m}^3$ have been measured at INDEM (one in 2006 and three in 2008).

- Although the maximum and 95th percentile increased from 2007 to 2008, the 1-year average, median, 5th percentile, and minimum concentrations of acetaldehyde all exhibit decreases from 2007 to 2008. Although three concentrations greater than $10 \mu\text{g}/\text{m}^3$ were measured in 2008 (compared to zero in 2007), the number of measurements at the lower end of the concentration range increased significantly. The number of acetaldehyde concentrations less than $2 \mu\text{g}/\text{m}^3$ increased seven-fold (from three in 2007 to 21 for 2008).
- With the exception of the minimum and 5th percentile, the statistical parameters decreased significantly from 2008 to 2009. The 1-year average and median concentrations decreased by more than half and the 95th percentile decreased by more than 80 percent during this time. The carbonyl compound samplers were switched out in 2009, which seems to have had a significant effect on the concentrations measured, particularly with respect to formaldehyde, which is discussed in more detail below.
- Most of the statistical parameters exhibit a slight decreasing trend between 2010 and 2013, with many of them at a minimum for 2013. The median concentration for 2013 is less than $1.00 \mu\text{g}/\text{m}^3$ for 2013 and the 1-year average concentration is close behind.

Figure 13-10. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at INDEM

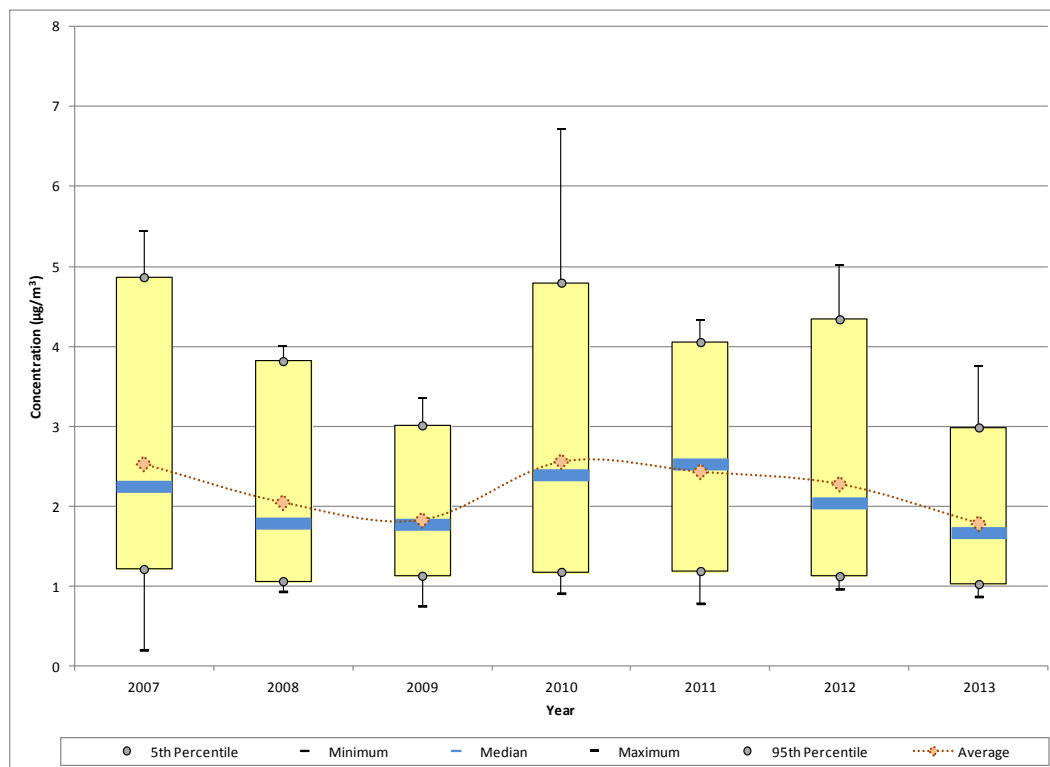


¹ A 1-year average is not presented due to a break in sampling between September 2005 and November 2005.

Observations from Figure 13-10 for formaldehyde measurements collected at INDEM include the following:

- Five formaldehyde concentrations greater than $400 \mu\text{g}/\text{m}^3$ were measured in the summer of 2008 (ranging from $414 \mu\text{g}/\text{m}^3$ to $500 \mu\text{g}/\text{m}^3$). While these are extremely high values of formaldehyde, concentrations of formaldehyde have been historically high at this site, as shown by the statistics in Figure 13-10. There have been 38 concentrations of formaldehyde greater than $100 \mu\text{g}/\text{m}^3$ measured at INDEM.
- Prior to 2009, the maximum concentration for each year is greater than $150 \mu\text{g}/\text{m}^3$. In addition, the median concentrations for 2004, 2006, and 2007 are greater than $30 \mu\text{g}/\text{m}^3$, indicating that at least half of the concentrations were greater than $30 \mu\text{g}/\text{m}^3$ for these years.
- Although the 1-year average concentration doubled from 2007 to 2008, the median concentration decreased by more than half. This means that although the magnitude of those higher measurements is driving the 1-year average concentration upward, there were a larger number of concentrations at the lower end of the concentration range as well. There were 24 formaldehyde concentrations measured in 2008 that were less than the minimum concentration measured in 2007; those 24 measurements represent 40 percent of the concentrations measured in 2008. The last “high” concentration was measured on August 10, 2008, after which no formaldehyde concentrations greater than $4 \mu\text{g}/\text{m}^3$ were measured in 2008.
- All the statistical metrics decreased significantly for 2009 and the years that follow, with the 1-year average concentrations ranging from $2.14 \mu\text{g}/\text{m}^3$ (2013) to $2.58 \mu\text{g}/\text{m}^3$ (2009). In contrast to the previous bullet, the number of measurements greater than $4 \mu\text{g}/\text{m}^3$ ranged from two to seven for each year between 2009 and 2013 (with the most measured in 2012).
- INDEM’s formaldehyde concentrations have historically been higher than any other NMP site sampling carbonyl compounds. During the summer PAMS season, which begins on June 1, a state-owned multi-channel collection system was used at INDEM to collect multiple samples per day. At the end of each PAMS season, sample collection goes back to a state-owned single-channel collection system. The multi-channel sampler used at INDEM during the PAMS season was replaced in 2009 and their formaldehyde concentrations decreased substantially (as did their acetaldehyde concentrations, but the difference is less dramatic). Given that the elevated concentrations of formaldehyde were typically measured during the summer, this sampler change could account for the differences in the concentrations for 2009-2012 compared to previous years. Thus, the elevated concentrations from previous years were likely related to the multi-channel collection equipment and may not reflect the actual levels in ambient air. However, concentrations in the earlier years of sampling must have still been higher based on the median concentrations shown before and after 2009, as discussed in the previous bullets.

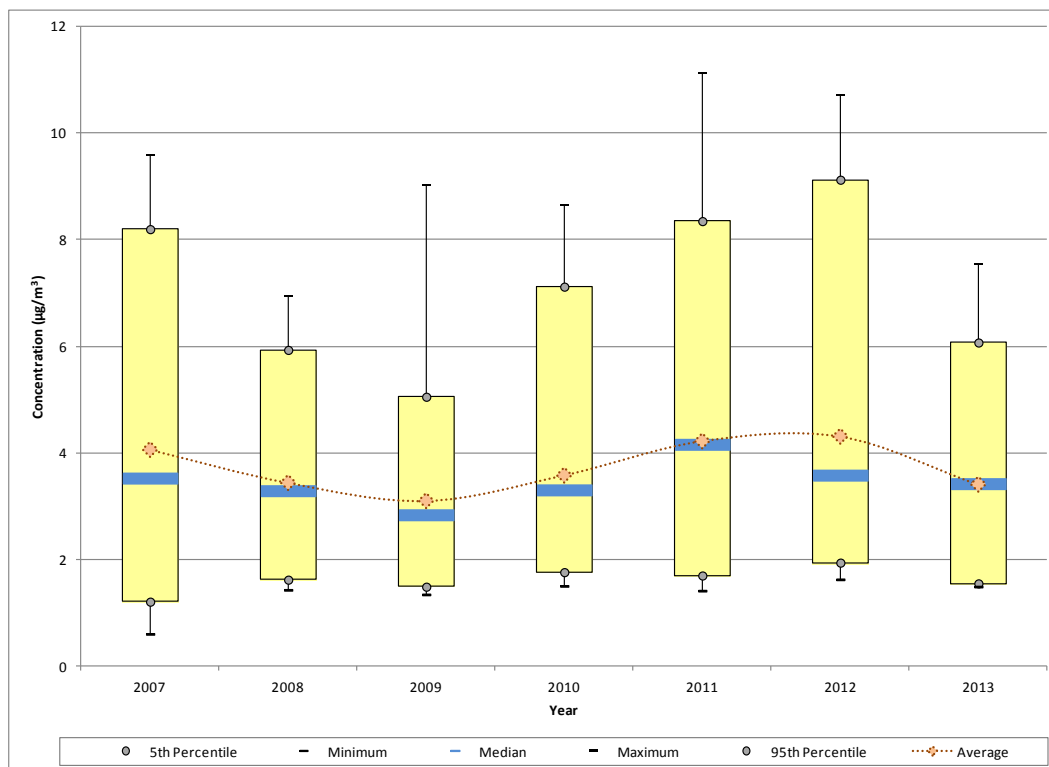
Figure 13-11. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at WPIN



Observations from Figure 13-11 for acetaldehyde measurements collected at WPIN include the following:

- Although carbonyl compound sampling under the NMP began in 2006, samples were collected intermittently. Carbonyl compound sampling began in earnest at WPIN at the beginning of 2007; thus, Figure 13-11 begins with 2007.
- The three highest acetaldehyde concentrations were measured at WPIN in 2010 and ranged from $5.96 \mu\text{g}/\text{m}^3$ to $6.72 \mu\text{g}/\text{m}^3$. Three additional concentrations greater than $5 \mu\text{g}/\text{m}^3$ have been measured at WPIN (two in 2007 and one in 2012).
- The 1-year average concentration has a decreasing trend through 2009, after which a significant increase is shown. For 2010, all of the statistical parameters increased, particularly the maximum (which doubled) and the 95th percentile (which increased by nearly 60 percent). The 1-year average concentration has a slight decreasing trend again after 2010, with the 1-year average concentration at a minimum for 2013 over the years of sampling.

Figure 13-12. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at WPIN



Observations from Figure 13-12 for formaldehyde measurements collected at WPIN include the following:

- The maximum concentration of formaldehyde measured at WPIN was measured in 2011 ($11.1 \mu\text{g}/\text{m}^3$). The next three highest concentrations were measured at WPIN in 2012 and ranged from $9.87 \mu\text{g}/\text{m}^3$ to $10.7 \mu\text{g}/\text{m}^3$.
- The 1-year average concentration has a decreasing trend through 2009, similar to acetaldehyde, after which an increasing trend is shown through 2012. Although the 1-year average concentration did not change significantly, the median concentration for 2012 decreased considerably. A review of the data for 2011 and 2012 shows that the number of concentrations in the $3 \mu\text{g}/\text{m}^3$ to $4 \mu\text{g}/\text{m}^3$ range doubled from 2011 to 2012 (from seven to 15); in addition, the number of concentrations in the $4 \mu\text{g}/\text{m}^3$ to $6 \mu\text{g}/\text{m}^3$ range decreased by nearly half (from 20 in 2011 to 11 in 2012). These changes explain the change in the median concentration while a few additional measurements in the upper end of the concentration range explain the increase in the 95th percentile.
- Nearly all of the statistical parameters exhibit decreases for 2013, particularly the 95th percentile.

13.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at each Indiana monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

13.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Indiana sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 13-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 13-6. Risk Approximations for the Indiana Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Gary, Indiana - INDEM						
Acetaldehyde	0.0000022	0.009	61/61	1.04 ± 0.09	2.29	0.12
Formaldehyde	0.000013	0.0098	61/61	2.14 ± 0.32	27.77	0.22
Indianapolis, Indiana - WPIN						
Acetaldehyde	0.0000022	0.009	58/58	1.78 ± 0.16	3.92	0.20
Formaldehyde	0.000013	0.0098	58/58	3.41 ± 0.37	44.34	0.35

Observations for the Indiana sites from Table 13-6 include the following:

- For both sites, the annual average concentration of formaldehyde is greater than the annual average concentration of acetaldehyde. The annual average concentrations for WPIN are greater than the annual averages for INDEM.
- The cancer risk approximation for formaldehyde is an order of magnitude higher than the cancer risk approximation for acetaldehyde for both sites. The cancer risk approximations for WPIN are nearly twice the cancer risk approximations for INDEM.
- The cancer risk approximation for formaldehyde for WPIN (44.34 in-a-million) is the sixth highest cancer risk approximation for formaldehyde program-wide and the seventh highest among all site-specific pollutants of interest across the program.
- Neither pollutant of interest for INDEM or WPIN have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The noncancer hazard approximation for WPIN ranks 10th highest among all pollutants of interest program-wide.

13.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 13-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 13-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 13-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 13-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 13-7. Table 13-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and

noncancer hazard approximations provided in Section 13.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 13-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the three highest emitted pollutants with cancer UREs in both Marion and Lake County, although the quantity emitted is roughly twice as high in Marion County.
- Coke oven emissions, POM, Group 1b, and formaldehyde, are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Lake County. Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions for Marion County.
- Six of the highest emitted pollutants in Lake County also have the highest toxicity-weighted emissions; seven of the highest emitted pollutants in Marion County also have the highest toxicity-weighted emissions.
- Acetaldehyde and formaldehyde are the only pollutants of interest for INDEM and WPIN. Acetaldehyde and formaldehyde appear among the highest emitted pollutants for both counties, with only formaldehyde appearing among the pollutants with the highest toxicity-weighted emissions.
- While several metals (arsenic, nickel, and hexavalent chromium) are among the pollutants with the highest toxicity-weighted emissions for both counties, none of these are among the highest emitted pollutants for either county. This demonstrates that a pollutant does not have to be emitted in large quantities to be toxic.
- Several POM Groups and naphthalene appear among the highest emitted pollutants and the pollutants with the highest toxicity-weighted emissions for both counties. Neither site sampled PAHs under the NMP.

Table 13-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Indiana Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Gary, Indiana (Lake County) - INDEM					
Benzene	177.07	Coke Oven Emissions, PM	2.38E-03	Formaldehyde	27.77
Formaldehyde	145.37	POM, Group 1b	1.92E-03	Acetaldehyde	2.29
Ethylbenzene	94.06	Formaldehyde	1.89E-03		
Acetaldehyde	84.11	Benzene	1.38E-03		
1,3-Butadiene	27.28	Hexavalent Chromium	9.67E-04		
POM, Group 1b	21.84	1,3-Butadiene	8.18E-04		
Naphthalene	13.35	Arsenic, PM	6.53E-04		
Tetrachloroethylene	9.35	Naphthalene	4.54E-04		
POM, Group 2b	2.78	POM, Group 2b	2.45E-04		
POM, Group 2d	2.68	Nickel, PM	2.38E-04		
Indianapolis, Indiana (Marion County) - WPIN					
Benzene	421.74	Formaldehyde	4.14E-03	Formaldehyde	44.34
Formaldehyde	318.24	Benzene	3.29E-03	Acetaldehyde	3.92
Ethylbenzene	268.73	1,3-Butadiene	1.87E-03		
Acetaldehyde	189.64	Naphthalene	1.11E-03		
1,3-Butadiene	62.21	Arsenic, PM	1.05E-03		
Tetrachloroethylene	33.59	Ethylbenzene	6.72E-04		
Naphthalene	32.73	POM, Group 2b	6.51E-04		
POM, Group 2b	7.40	Nickel, PM	5.08E-04		
POM, Group 2d	5.22	POM, Group 2d	4.60E-04		
Propylene oxide	4.72	Hexavalent Chromium	4.20E-04		

Table 13-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Indiana Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Gary, Indiana (Lake County) - INDEM					
Toluene	669.66	Acrolein	476,219.32	Formaldehyde	0.22
Xylenes	436.89	Lead, PM	52,690.40	Acetaldehyde	0.12
Hexane	427.58	Manganese, PM	22,492.64		
Methanol	328.00	Hydrochloric acid	16,187.23		
Hydrochloric acid	323.74	Formaldehyde	14,834.03		
Benzene	177.07	1,3-Butadiene	13,641.59		
Formaldehyde	145.37	Chlorine	12,016.67		
Ethylene glycol	98.80	Arsenic, PM	10,126.34		
Ethylbenzene	94.06	Acetaldehyde	9,345.56		
Acetaldehyde	84.11	Benzene	5,902.45		
Indianapolis, Indiana (Marion County) - WPIN					
Toluene	1,660.99	Acrolein	1,224,556.10	Formaldehyde	0.35
Xylenes	1,008.89	Formaldehyde	32,473.78	Acetaldehyde	0.20
Hexane	773.82	1,3-Butadiene	31,104.81		
Methanol	532.81	Hydrochloric acid	23,337.36		
Hydrochloric acid	466.75	Acetaldehyde	21,070.71		
Benzene	421.74	Arsenic, PM	16,282.89		
Formaldehyde	318.24	Benzene	14,057.94		
Ethylbenzene	268.73	Lead, PM	13,691.58		
Ethylene glycol	203.01	Nickel, PM	11,766.86		
Acetaldehyde	189.64	Naphthalene	10,909.09		

Observations from Table 13-8 include the following:

- Toluene, xylenes, and hexane are the three highest emitted pollutants with cancer UREs in both Marion and Lake County, although the quantity emitted is roughly twice as high in Marion County.
- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties. Lead and manganese rank second and third for Lake County, while formaldehyde and 1,3-butadiene rank second and third for Marion County.
- Four of the highest emitted pollutants in Lake County also have the highest toxicity-weighted emissions (formaldehyde, acetaldehyde, benzene, and hydrochloric acid). The same four pollutants appear on both emissions-based lists for Marion County.
- Several metals are among the pollutants with the highest toxicity-weighted emissions for Lake and Marion Counties, although none of these appear among the highest emitted pollutants.
- Formaldehyde and acetaldehyde appear in all three columns in Table 13-8 for both sites.

13.6 Summary of the 2013 Monitoring Data for INDEM and WPIN

Results from several of the data treatments described in this section include the following:

- ❖ *Carbonyl compounds were sampled for at INDEM and WPIN in 2013. Acetaldehyde and formaldehyde failed screens for each site and were identified as pollutants of interest for each site.*
- ❖ *The annual average concentration of formaldehyde is greater than the annual average concentration of acetaldehyde for both sites, with the annual averages for WPIN greater than the annual averages for INDEM.*
- ❖ *Concentrations of formaldehyde and acetaldehyde exhibited a significant decreasing trend at INDEM from 2008 to 2009; these changes may be at least partially explained by a sampler replacement.*

14.0 Sites in Kentucky

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Kentucky, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

14.1 Site Characterization

This section characterizes the Kentucky monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

Data from 10 monitoring sites in Kentucky are included in this section. Three monitoring sites are located in northeast Kentucky, two in Ashland and one near Grayson Lake. One monitoring site is located south of Evansville, Indiana. Five monitoring sites are located in or near the Calvert City area, east of Paducah, Kentucky. The final monitoring site is located in Lexington, in north-central Kentucky. A composite satellite image and facility map is provided for each site in Figures 14-1 through 14-15. The composite satellite images were retrieved from ArcGIS Explorer and show each monitoring site in its respective location. The facility maps identify nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of each site are included in the facility counts provided. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at each monitoring site. Further, this boundary provides both the proximity of emissions sources to each monitoring site as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile boundaries are still visible on the maps for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 14-1 provides supplemental geographical information such as land use, location setting, and locational coordinates for each site.

Figure 14-1. Ashland, Kentucky (ASKY) Monitoring Site

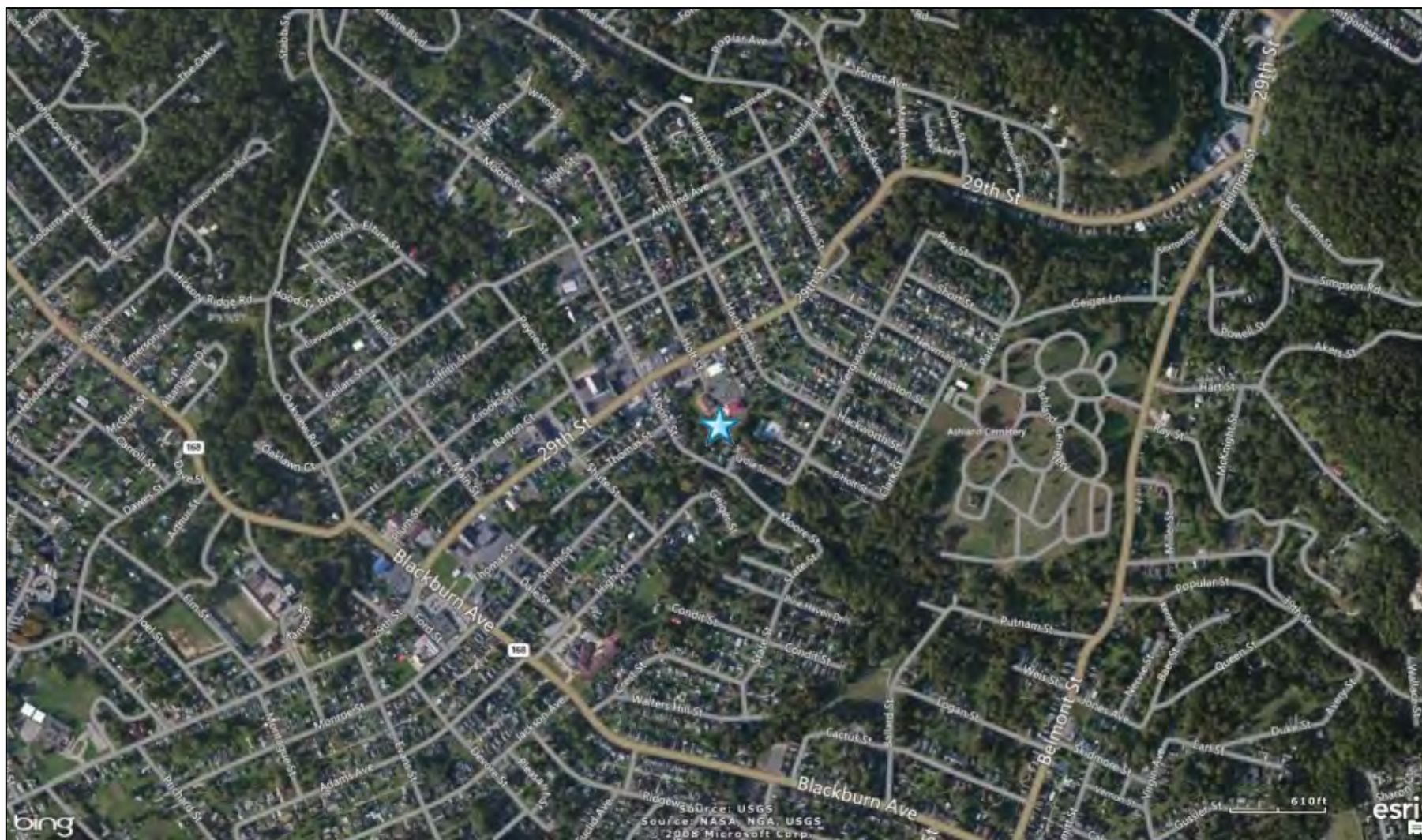


Figure 14-2. Ashland, Kentucky (ASKY-M) Monitoring Site

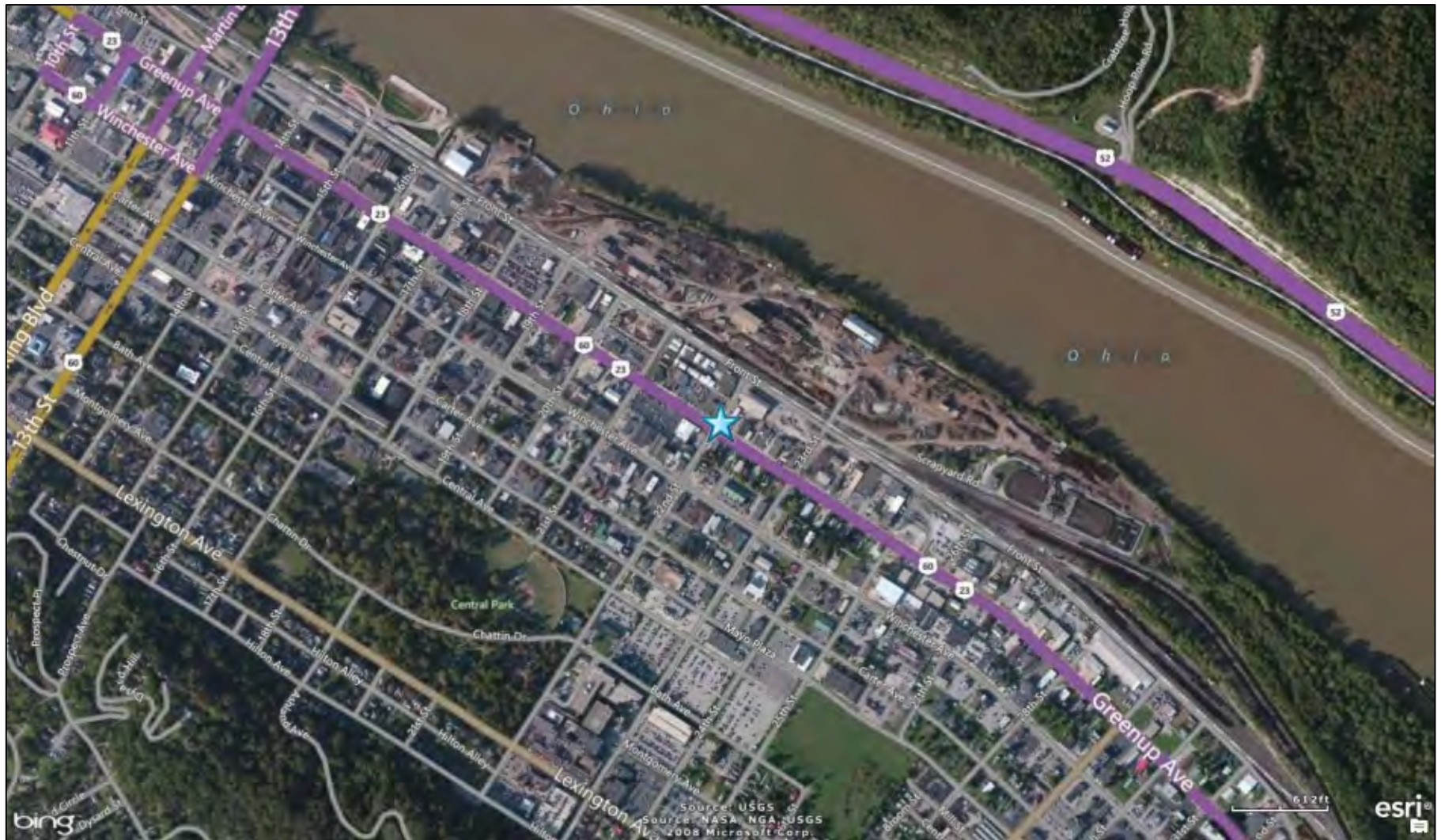


Figure 14-3. NEI Point Sources Located Within 10 Miles of ASKY and ASKY-M

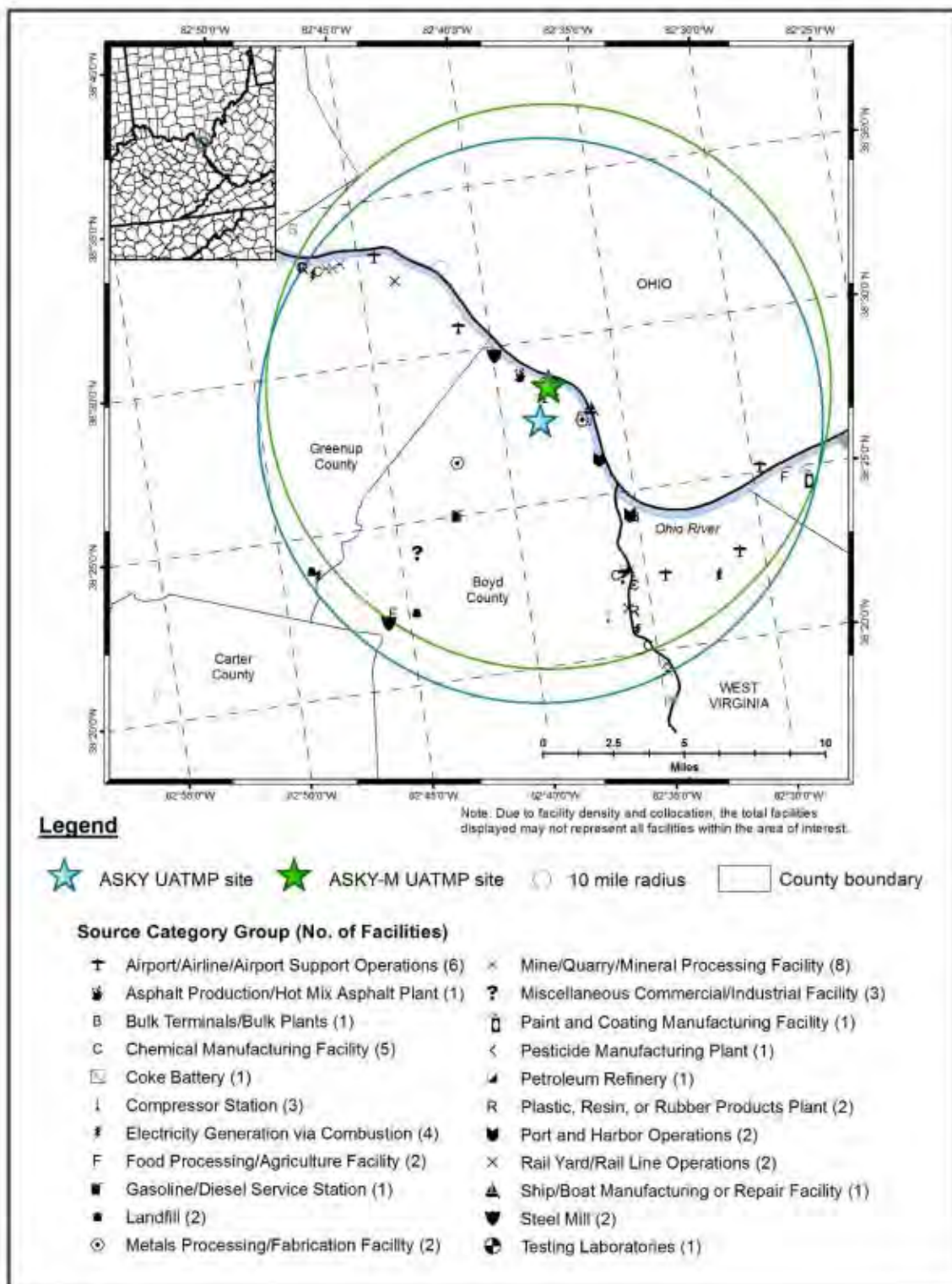


Figure 14-4. Grayson, Kentucky (GLKY) Monitoring Site



Figure 14-5. NEI Point Sources Located Within 10 Miles of GLKY

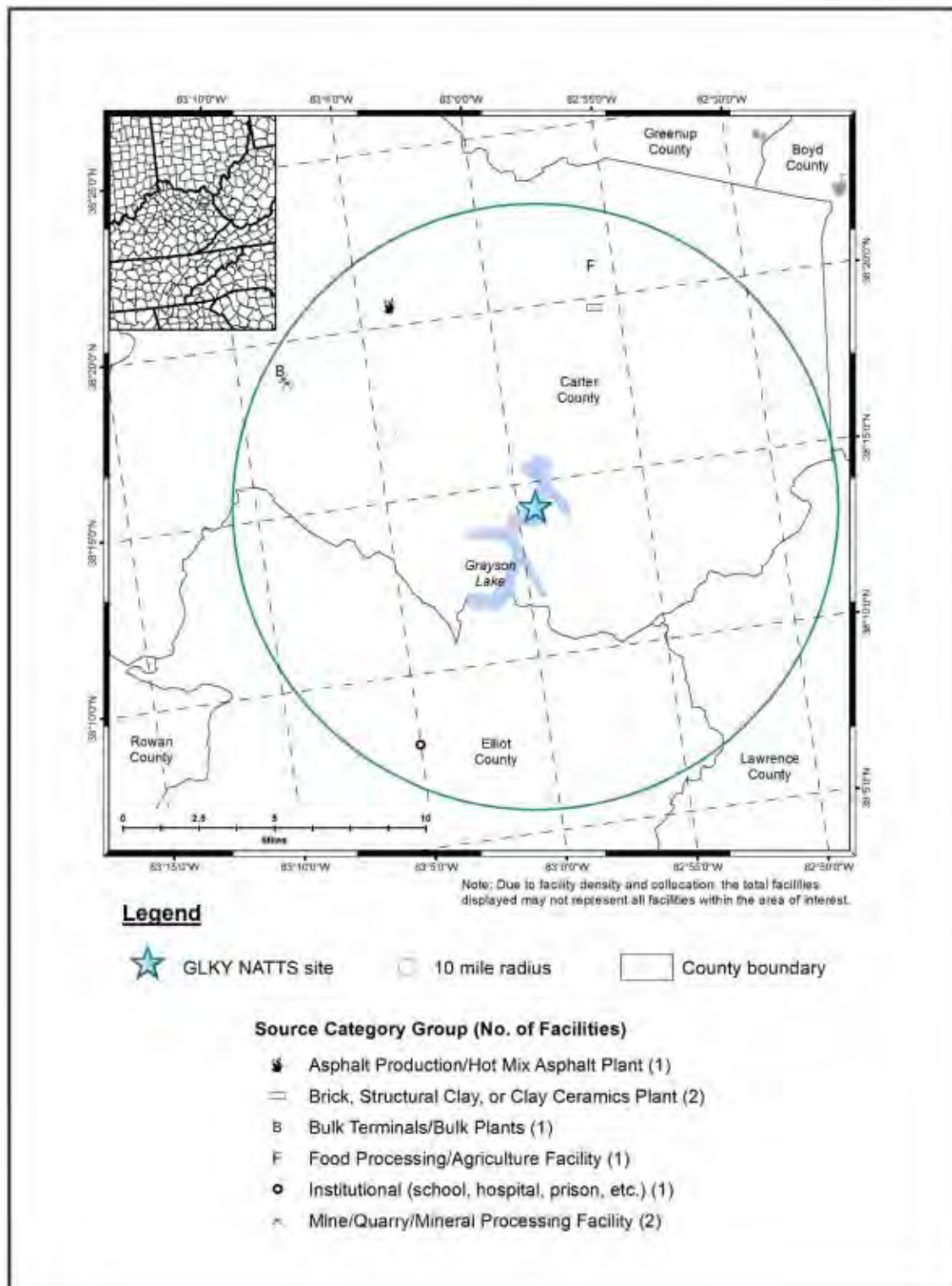


Figure 14-6. Baskett, Kentucky (BAKY) Monitoring Site

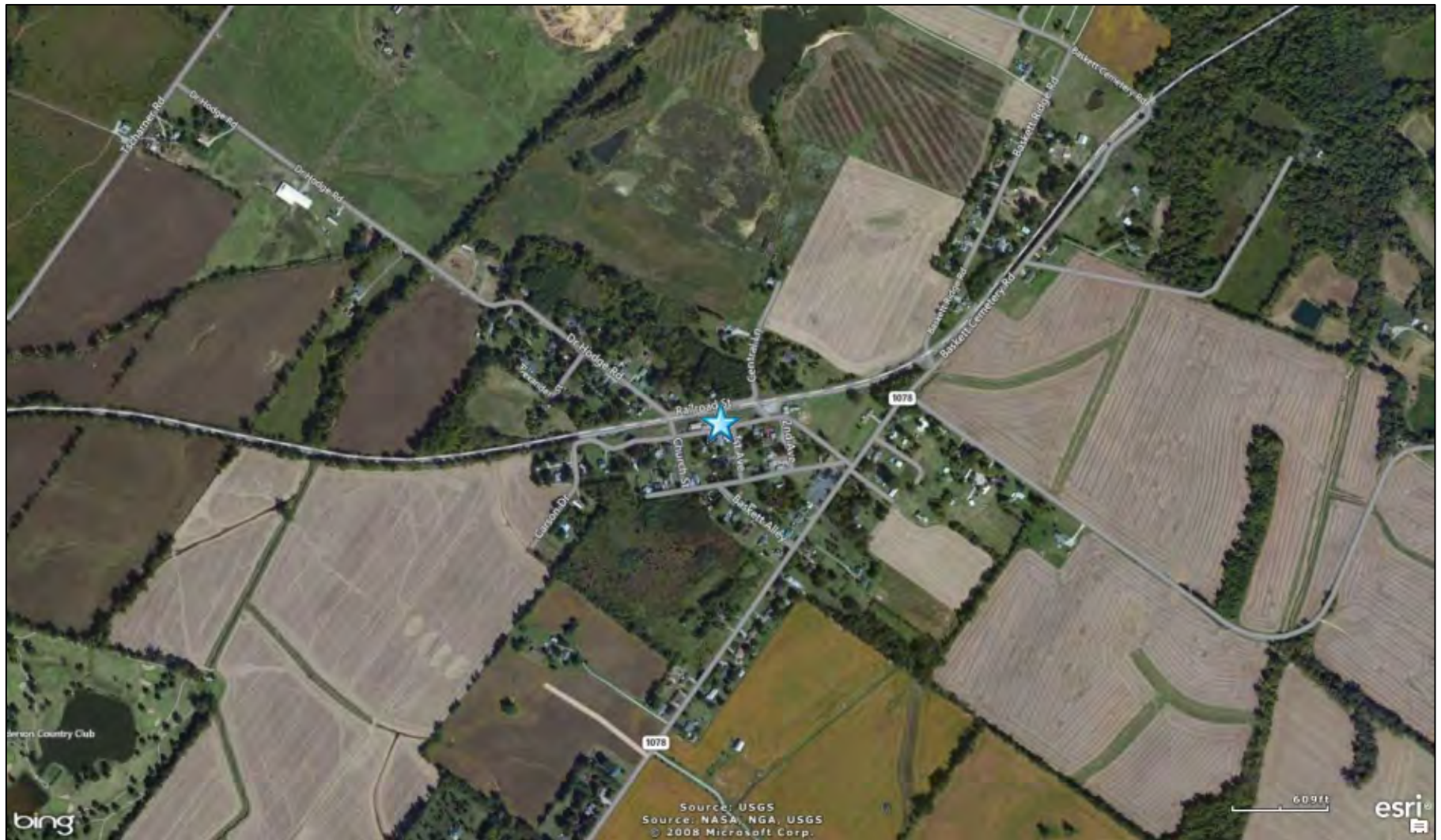
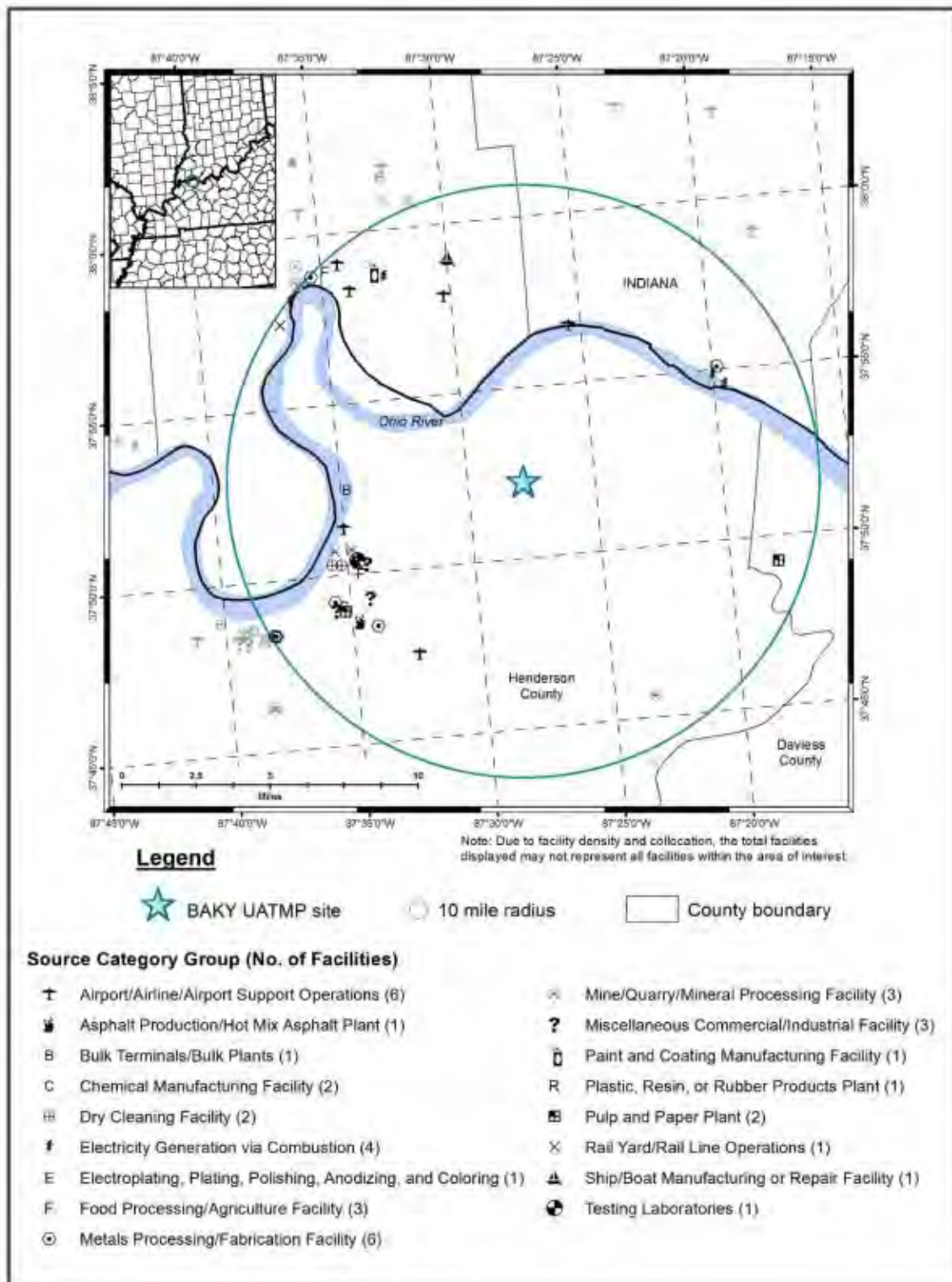


Figure 14-7. NEI Point Sources Located Within 10 Miles of BAKY



14-9



Figure 14-9. Smithland, Kentucky (BLKY) Monitoring Site



Figure 14-10. Calvert City, Kentucky (CCKY) Monitoring Site

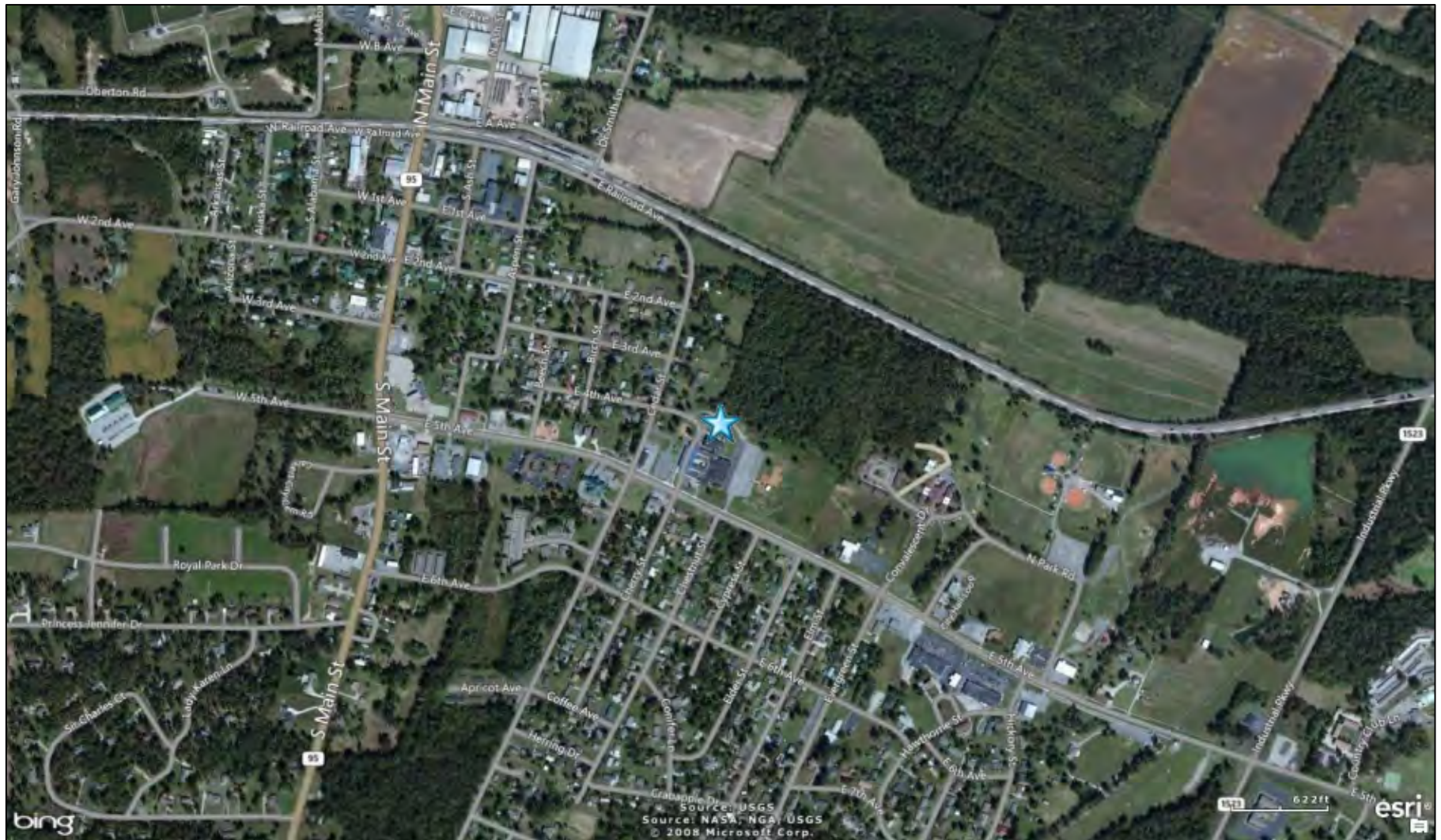


Figure 14-11. Calvert City, Kentucky (LAKY) Monitoring Site



Figure 14-12. Calvert City, Kentucky (TVKY) Monitoring Site

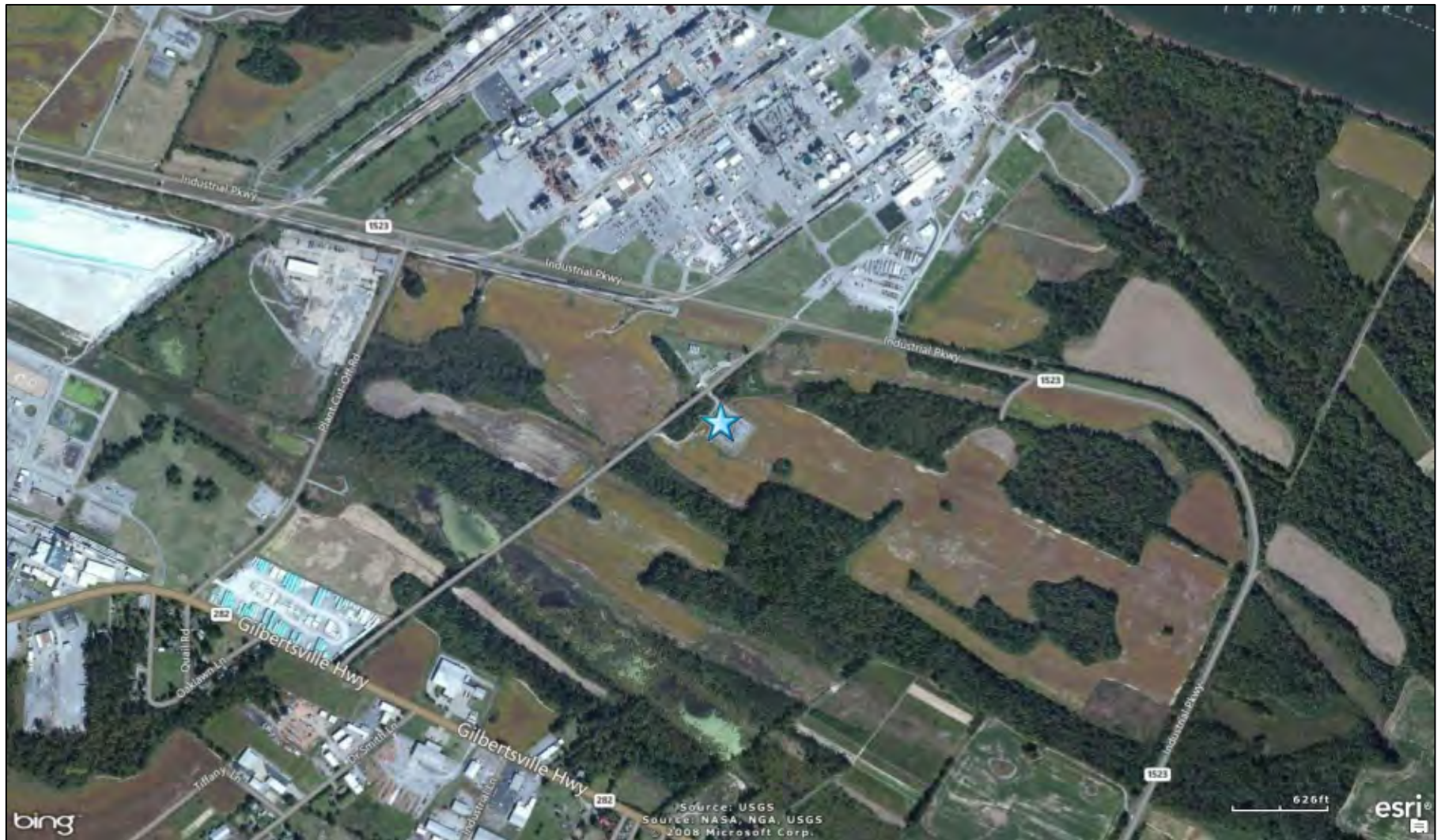


Figure 14-13. NEI Point Sources Located Within 10 Miles of ATKY, BLKY, CCKY, LAKY, and TVKY

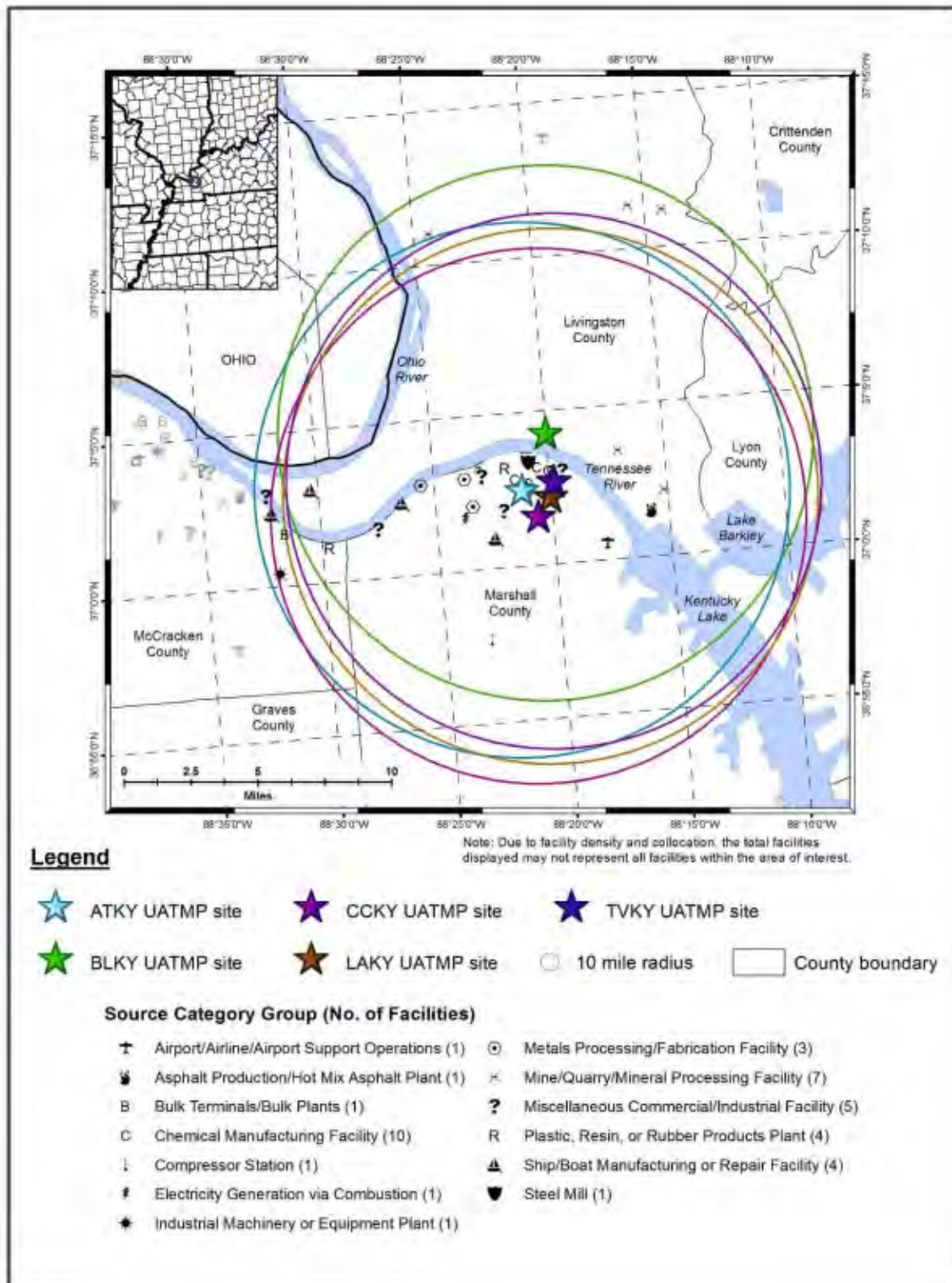


Figure 14-14. Lexington, Kentucky (LEKY) Monitoring Site

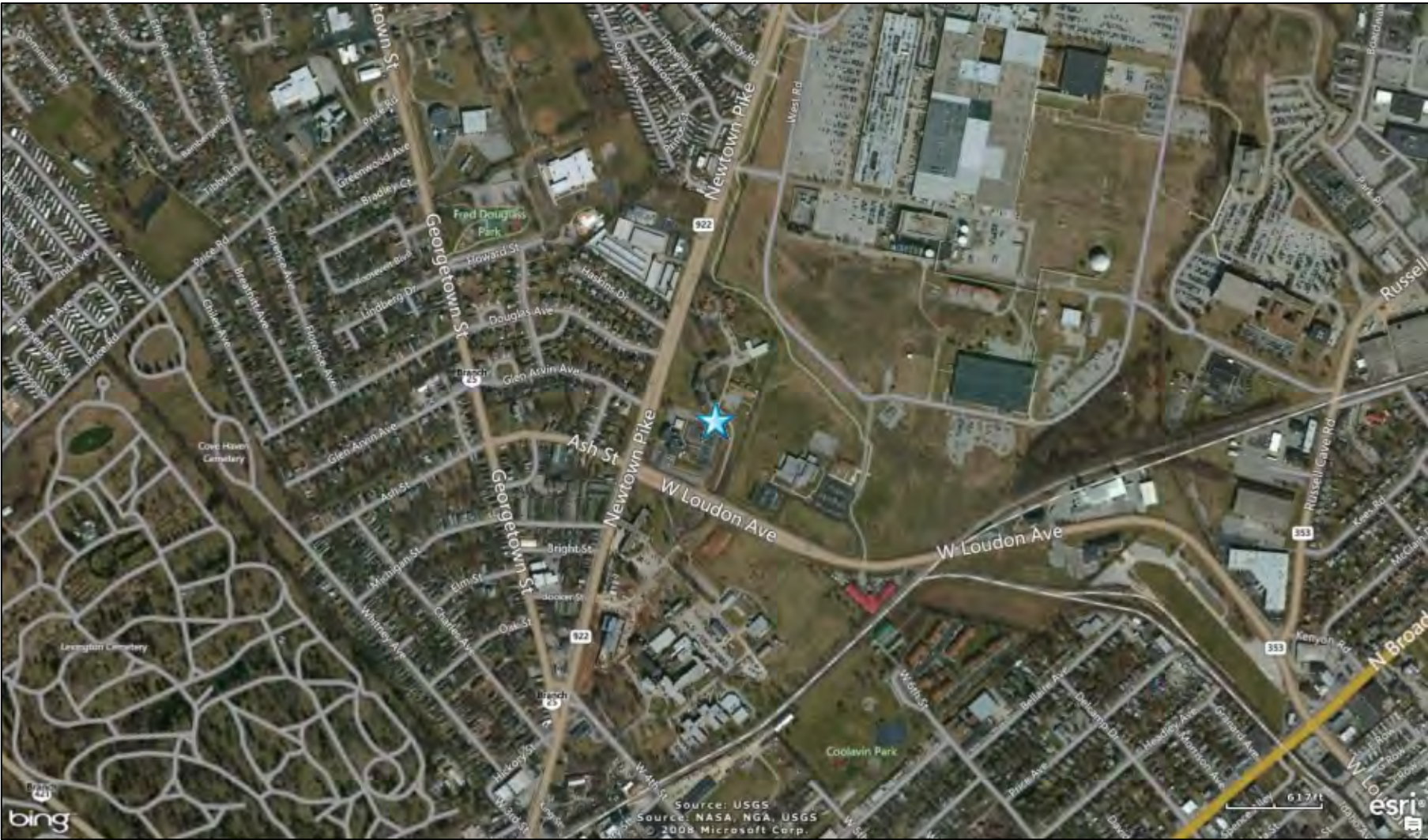


Figure 14-15. NEI Point Sources Located Within 10 Miles of LEKY

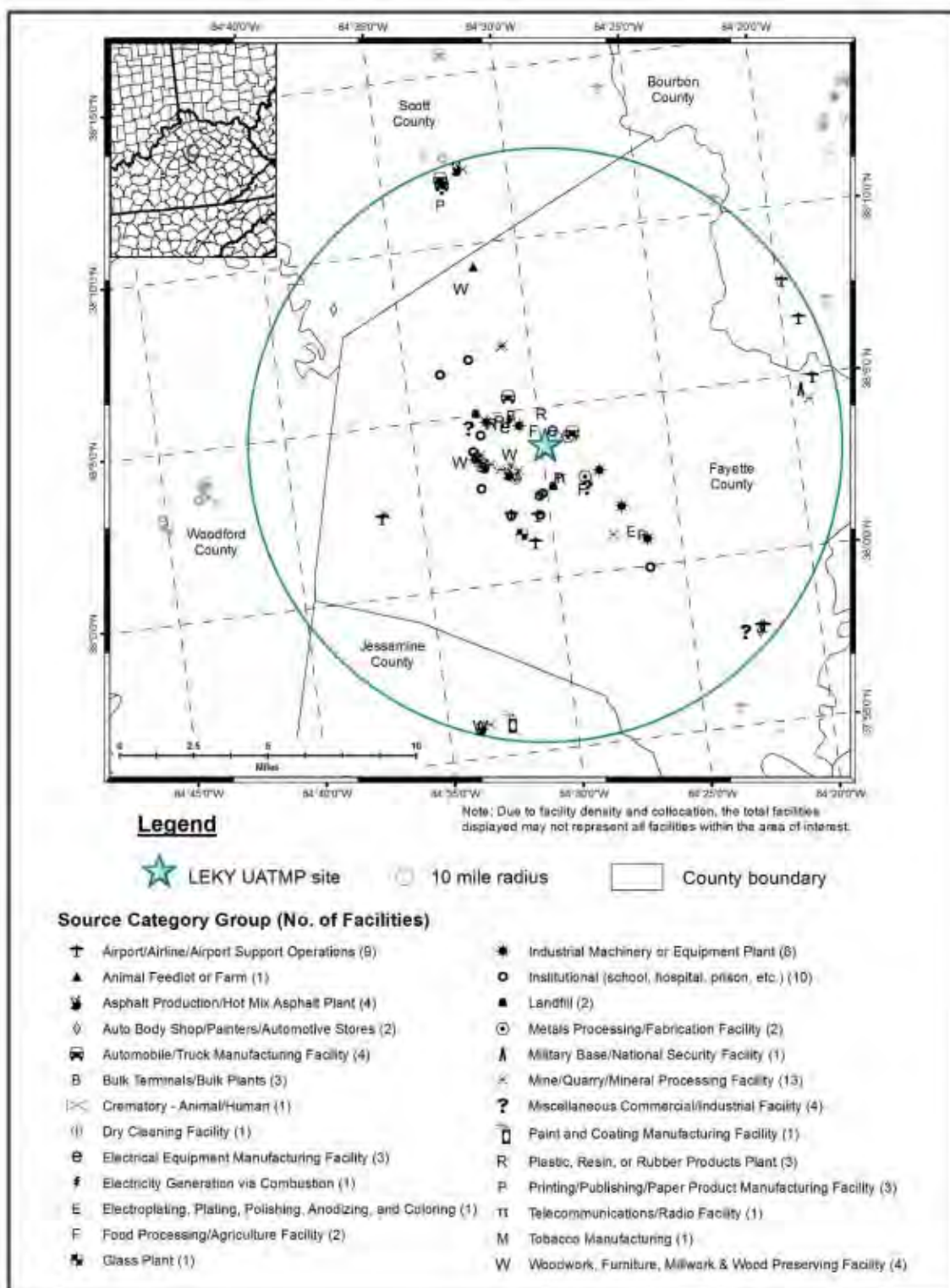


Table 14-1. Geographical Information for the Kentucky Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
ASKY	21-019-0017	Ashland	Boyd	Huntington-Ashland, WV-KY-OH	38.45934, -82.64041	Residential	Suburban	SO ₂ , NO, NO ₂ , O ₃ , Meteorological parameters, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
ASKY-M	21-019-0002	Ashland	Boyd	Huntington-Ashland, WV-KY-OH	38.476, -82.63137	Industrial	Urban/City Center	PM ₁₀ .
GLKY	21-043-0500	Grayson	Carter	None	38.23887, -82.9881	Residential	Rural	O ₃ , Meteorological parameters, PM ₁₀ , PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
BAKY	21-101-0014	Baskett	Henderson	Evansville, IN-KY	37.8712, -87.46375	Commercial	Rural	SO ₂ , O ₃ , Meteorological parameters, PM ₁₀ , PM _{2.5} , PM _{2.5} Speciation.
ATKY	21-157-0016	Calvert City	Marshall	None	37.04176, -88.35407	Industrial	Suburban	None.
BLKY	21-139-0004	Smithland	Livingston	Paducah, KY-IL	37.07151, -88.33389	Agricultural	Rural	Meteorological parameters.
CCKY	21-157-0018	Calvert City	Marshall	None	37.02702, -88.34387	Residential	Suburban	Meteorological parameters, PM ₁₀ .
LAKY	21-157-0019	Calvert City	Marshall	None	37.03718, -88.33411	Residential	Suburban	None.
TVKY	21-157-0014	Calvert City	Marshall	None	37.0452, -88.33087	Industrial	Suburban	None.
LEKY	21-067-0012	Lexington	Fayette	Lexington-Fayette, KY	38.06503, -84.49761	Residential	Suburban	SO ₂ , NO, NO ₂ , O ₃ , Meteorological parameters, PM ₁₀ , PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

There are two Kentucky monitoring sites in the town of Ashland. Ashland is located on the Ohio River, just north of where the borders of Kentucky, West Virginia, and Ohio meet, and is part of the Huntington-Ashland, WV-KY-OH CBSA. The ASKY site is located behind the county health department, which is nestled in a residential area in the center of town, as shown in Figure 14-1. The ASKY-M site is located on the roof of an oil company complex in the north-central part of Ashland, which is more industrial. The monitoring site is located less than one-quarter mile from the Ohio River, and a rail yard, a scrap yard, and other industries are located between ASKY-M and the river, as shown in Figure 14-2. The ASKY-M monitoring site is located on Greenup Road (Route 60/23), a major thoroughfare through downtown Ashland.

ASKY and ASKY-M are approximately 1.25 miles apart, as shown in Figure 14-3. Most of the emissions sources near these sites are located along the Ohio River and its tributary to the south, the Big Sandy River. These emissions sources are involved in a variety of industries including asphalt production, chemical manufacturing, food processing, metals processing/fabrication, pesticide manufacturing, petroleum refining, and ship/boat manufacturing, to name a few. A cluster of emissions sources is located very close to ASKY-M, within a half-mile, such that the symbol for the site hides the symbols for the facilities. This cluster includes a testing laboratory, a miscellaneous commercial/industrial facility, a mine/quarry, and a heliport at a hospital. There are no emissions sources within a half-mile of ASKY. The closest sources to ASKY are the same ones under the symbol for ASKY-M, although a metals processing/fabrication facility and coke battery are located a little farther to the east of ASKY.

Grayson Lake is located in northeast Kentucky, south of the town of Grayson, and southwest of the Huntington-Ashland, WV-KY-OH CBSA. The Little Sandy River feeds into Grayson Lake, which is a U.S. Army Corps of Engineers-managed project, and part of the Kentucky State Parks system. The lake is narrow and winding, with sandstone cliffs rising to up to 200 feet above the lake surface (KY, 2015; ACE, 2015). The closest road to the monitoring site is a service road feeding into Camp Grayson, as shown in Figure 14-4. This site serves as the Grayson Lake NATTS site. Figure 14-5 shows that few point sources surround GLKY and that most of them are on the outer periphery of the 10-mile boundary around GLKY. This is not surprising given the rural nature of the area and that Grayson Lake is located roughly in the center of the 10-mile radius in Figure 14-5. Sources within 10 miles of GLKY are involved in

asphalt production, brick/structural clay/clay ceramics manufacturing, food processing, and mining, among others.

The BAKY monitoring site is located at the Baskett Fire Department in Baskett, a small rural town in northwest Kentucky. Baskett is northeast of Henderson and south of Evansville, Indiana. The Ohio River is the border between Kentucky and Indiana and meanders through the area, with the Green River, a tributary of the Ohio River, just over 1 mile north of the site at the closest point. The fire department property backs up to a railroad that runs through town. Open fields surround the town, as shown in Figure 14-6, and there are no emissions sources within a few miles of BAKY, as shown in Figure 14-7. The cluster of emissions sources to the southwest of BAKY are located in or near Henderson, while the sources to the northwest are located in Evansville.

There are five monitoring sites in and around the Calvert City area. Calvert City is located on the Tennessee River, east of the Paducah metro area, approximately 6 miles southeast of the Ohio River and the Kentucky/Illinois border. The northern half of the city is highly industrialized while the southern half is primarily residential, with a railroad that transverses the area acting as a pseudo-dividing line. The city is home to some 17 industrial plants, including metal, steel, and chemical plants (Calvert City, 2015).

The ATKY monitoring site is located off Main Street (State Road 95), just south of the entrance to a chemical manufacturing plant. The majority of the city's industry lies north and east of ATKY. Approximately 1 mile east-southeast down Gilbertsville Highway is the LAKY monitoring site. LAKY is located behind a mobile home park. Although located in a residential area, industrial areas are located to the west, northwest, and north. Just over one-half mile north of LAKY is the TVKY monitoring site. This monitoring site is located at a power substation just south of another chemical manufacturing plant. The fourth monitoring site in Calvert City is located at Calvert City Elementary School. The CCKY site is located behind the school, which backs up to a forested area just south of the aforementioned railroad and to the south of most of the industry. The BLKY site is located across the Tennessee River, north of Calvert City, in Smithland. The site is located on a residential property in an agricultural area. This site is potentially downwind of the Calvert City industrial area. The composite satellite images for these sites are provided in alphabetical order by site in Figures 14-8 through 14-12.

Figure 14-13 is the facility map for the Calvert City sites and provides an indication of how close these sites are to one another. Most of the emissions sources in Calvert City are located between ATKY, LAKY, and the Tennessee River. Many of the emissions sources closest to the Calvert City sites are in the chemical manufacturing source category. There are also several plastic, resin, or rubber product plants located between these sites. Industries located farther away from the sites but within 10 miles include ship/boat manufacturing or repair; mine, quarry, or mineral processing; a steel mill; metals processing/fabrication, and an asphalt production/hot mix asphalt plant.

The LEKY monitoring site is located in the city of Lexington in north-central Kentucky. The site is located on the property of the county health department in a primarily residential area of northern Lexington. A YMCA is located adjacent to the health department along W. Loudon Avenue and a community college is located immediately to the south. The mental health facility formerly located on the property has been demolished after relocating. Although the area is classified as residential and suburban, most of the residences are located to the west of Newtown Pike (922). A major electrical equipment and ink manufacturer is located to the northeast of the site, as shown in Figure 14-14. LEKY is located just over a half-mile south of New Circle Road (4/421), a loop encircling the city of Lexington.

Figure 14-15 shows that most of the emissions sources within 10 miles of LEKY are within a few miles of the site. Emissions sources within 1 mile of LEKY include a food processing plant, the aforementioned electrical equipment manufacturing plant, a crematory, a metals processing and fabrication facility, and an automobile/truck manufacturing facility.

Table 14-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Kentucky monitoring sites. Table 14-2 includes both county-level population and vehicle registration information. Table 14-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 14-2 presents the county-level daily VMT for Boyd, Carter, Henderson, Marshall, Livingston, and Fayette Counties.

Table 14-2. Population, Motor Vehicle, and Traffic Information for the Kentucky Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
ASKY	Boyd	48,886	39,196	7,230	29th St between Newman St and Lynwood Ave	1,256,000
ASKY-M				12,842	Greenup (23rd) between 16th St and 17th St	
GLKY	Carter	27,202	25,487	303	Rd 1496, S of Camp Webb Rd	1,076,000
BAKY	Henderson	46,347	38,811	922	Rte 1078 N of Hwy 60	1,366,000
ATKY	Marshall	31,107	30,254	3,262	Main St (Rte 95), S of Johnson Riley Rd	1,241,000
CCKY				4,050	Industrial Pkwy, S of E 5th Ave	
LAKY				1,189	Rte 282 (Gilbertsville Hwy), E of Industrial Ln	
TVKY				2,230	Industrial Pkwy (Rte 1523), E of Plant Cut-off Rd	
BLKY	Livingston	9,359	8,338	2,510	Rte 93/453	391,000
LEKY	Fayette	308,428	208,983	10,083	W Loudon Ave, E of Newton Pike	7,490,000

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect 2013 data (KYTC, 2014a)

³AADT reflects 2011 data for ASKY & TVKY; 2012 data for ASKY-M, GLKY, LEKY, BAKY, ATKY, and LAKY; and 2013 data for BLKY and CCKY (KYTC, 2014b)

⁴County-level VMT reflects 2013 data (KYTC, 2014c)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 14-2 include the following:

- Fayette County (LEKY) is the most populous of the Kentucky counties with monitoring sites (by an order of magnitude). Yet this county ranks 31st in population compared to other counties with NMP sites. The remaining Kentucky counties are among the least populated compared to other counties with NMP sites. Livingston County (BLKY) is the least populated of all counties with NMP sites, followed by Carter County (GLKY) as the second least populated, Marshall County (the Calvert City sites) third, Henderson County (BAKY) fifth, and Boyd County (ASKY/ASKY-M) sixth.
- All of the Kentucky counties with NMP sites rank among the bottom third for county-level vehicle ownership, with Fayette County ranking 34th and the remaining five Kentucky counties accounting for the bottom five county-level vehicle counts.
- Traffic is highest near ASKY-M and LEKY and lowest near GLKY and BAKY. Traffic counts for all of the Kentucky sites are in the bottom half of the range compared to other NMP sites, with the traffic near GLKY the lowest among all NMP sites.

- The daily VMT for Fayette County is significantly higher than the VMT for the other Kentucky counties. The VMT for Fayette County is in the middle of the range compared to other counties with NMP sites, while the other five Kentucky counties account for five of the six lowest county-level VMTs. Livingston County (BLKY) has the lowest county-level VMT among NMP sites.

14.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Kentucky on sample days, as well as over the course of the year.

14.2.1 Climate Summary

The monitoring sites in Kentucky are spread across four different regions across the state. Elevation generally increases from west to east, with the famed Bluegrass Region in the north-central portion of the state. The state of Kentucky experiences a continental climate, where conditions tend to be slightly cooler and drier in the northeast portion of the state and warmer and wetter in the southwest portion. Kentucky's mid-latitude location ensures an active weather pattern, in a convergence zone between cooler air from the north and warm, moist air from the south. The state enjoys all four seasons. Summers are persistently warm and humid; winters are cloudy but not harsh; and spring and fall are considered pleasant. Precipitation is well distributed throughout the year, although fall tends to be driest and spring wettest (NCDC, 2015).

14.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the Kentucky monitoring sites (NCDC, 2013), as described in Section 3.4.2. The closest weather station to each site is as follows: For ASKY, ASKY-M, and GLKY, Tri-State/M.J. Ferguson Field Airport (WBAN 03860); for BAKY, Evansville Regional Airport (WBAN 93817); for BLKY, ATKY, CCKY, LAKY, and TVKY, Barkley Regional Airport (WBAN 03816); and for LEKY, Blue Grass Airport (WBAN 93820). Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 14-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 14-3. Average Meteorological Conditions near the Kentucky Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Health Department, Ashland, Kentucky - ASKY									
Tri-St/M.J. Ferguson Field Airport 03860 (38.37, -82.56)	8.0 miles	Sample Days (66)	63.3 ± 4.8	54.3 ± 4.4	43.4 ± 4.8	49.0 ± 4.2	69.7 ± 3.6	1019.1 ± 1.6	4.3 ± 0.5
	145° (SE)	2013	64.7 ± 1.9	55.4 ± 1.7	44.7 ± 1.9	50.2 ± 1.7	70.5 ± 1.4	1018.3 ± 0.6	4.1 ± 0.2
21st and Greenup, Ashland, Kentucky - ASKY-M									
Tri-St/M.J. Ferguson Field Airport 03860 (38.37, -82.56)	8.7 miles	Sample Days (62)	64.2 ± 5.0	55.1 ± 4.6	44.8 ± 4.9	50.0 ± 4.3	71.1 ± 3.4	1018.9 ± 1.7	4.3 ± 0.5
	152° (SE)	2013	64.7 ± 1.9	55.4 ± 1.7	44.7 ± 1.9	50.2 ± 1.7	70.5 ± 1.4	1018.3 ± 0.6	4.1 ± 0.2
Grayson, Kentucky - GLKY									
Tri-St/M.J. Ferguson Field Airport 03860 (38.37, -82.56)	25.1 miles	Sample Days (66)	63.6 ± 4.8	54.6 ± 4.5	44.1 ± 4.8	49.5 ± 4.2	70.7 ± 3.3	1018.9 ± 1.6	4.4 ± 0.5
	70° (ENE)	2013	64.7 ± 1.9	55.4 ± 1.7	44.7 ± 1.9	50.2 ± 1.7	70.5 ± 1.4	1018.3 ± 0.6	4.1 ± 0.2
Baskett, Kentucky - BAKY									
Evansville Regional Airport 93817 (38.04, -87.52)	12.3 miles	Sample Days (62)	63.0 ± 5.4	55.0 ± 5.0	44.5 ± 5.1	49.8 ± 4.6	69.9 ± 2.7	1019.2 ± 1.9	5.6 ± 0.6
	345° (NNW)	2013	64.9 ± 2.0	55.9 ± 1.9	45.3 ± 1.9	50.6 ± 1.8	69.6 ± 1.0	1018.5 ± 0.7	5.3 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 14-3. Average Meteorological Conditions near the Kentucky Monitoring Sites (Continued)

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Atmos Energy, Calvert City, Kentucky - ATKY									
Barkley Regional Airport 03816 (37.06, -88.77)	23.3 miles	Sample Days (61)	64.7 ± 5.1	56.5 ± 4.8	47.0 ± 5.0	51.7 ± 4.5	72.6 ± 2.9	1018.4 ± 1.8	5.7 ± 0.7
	273° (W)	2013	66.3 ± 1.9	57.1 ± 1.8	47.2 ± 1.9	52.1 ± 1.7	71.8 ± 1.1	1018.0 ± 0.7	5.3 ± 0.3
Smithland, Kentucky - BLKY									
Barkley Regional Airport 03816 (37.06, -88.77)	24.4 miles	Sample Days (61)	64.3 ± 5.0	56.0 ± 4.8	46.4 ± 5.1	51.2 ± 4.5	72.3 ± 2.8	1018.4 ± 1.8	5.6 ± 0.7
	268° (W)	2013	66.3 ± 1.9	57.1 ± 1.8	47.2 ± 1.9	52.1 ± 1.7	71.8 ± 1.1	1018.0 ± 0.7	5.3 ± 0.3
Calvert City Elementary, Calvert City, Kentucky - CCKY									
Barkley Regional Airport 03816 (37.06, -88.77)	23.9 miles	Sample Days (63)	65.3 ± 5.0	56.9 ± 4.7	47.3 ± 5.0	52.0 ± 4.5	72.2 ± 2.7	1018.4 ± 1.8	5.6 ± 0.7
	275° (W)	2013	66.3 ± 1.9	57.1 ± 1.8	47.2 ± 1.9	52.1 ± 1.7	71.8 ± 1.1	1018.0 ± 0.7	5.3 ± 0.3
Lazy Daze, Calvert City, Kentucky - LAKY									
Barkley Regional Airport 03816 (37.06, -88.77)	24.4 miles	Sample Days (63)	64.1 ± 4.9	55.7 ± 4.7	46.0 ± 4.9	50.8 ± 4.4	72.0 ± 2.8	1018.5 ± 1.8	5.6 ± 0.7
	273° (W)	2013	66.3 ± 1.9	57.1 ± 1.8	47.2 ± 1.9	52.1 ± 1.7	71.8 ± 1.1	1018.0 ± 0.7	5.3 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 14-3. Average Meteorological Conditions near the Kentucky Monitoring Sites (Continued)

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
TVA Substation, Calvert City, Kentucky - TVKY									
Barkley Regional Airport 03816 (37.06, -88.77)	24.5 miles	Sample Days (61)	64.6 ± 5.1	56.3 ± 4.8	46.7 ± 5.1	51.5 ± 4.6	72.3 ± 2.8	1018.4 ± 1.8	5.6 ± 0.7
	272° (W)	2013	66.3 ± 1.9	57.1 ± 1.8	47.2 ± 1.9	52.1 ± 1.7	71.8 ± 1.1	1018.0 ± 0.7	5.3 ± 0.3
Lexington, Kentucky - LEKY									
Blue Grass Airport 93820 (38.04, -84.61)	6.1 miles	Sample Days (62)	62.9 ± 5.1	54.7 ± 4.8	45.2 ± 4.9	49.9 ± 4.5	72.5 ± 3.0	1019.1 ± 1.7	7.2 ± 0.7
	254° (WSW)	2013	64.2 ± 1.9	55.4 ± 1.8	45.6 ± 1.9	50.5 ± 1.7	71.9 ± 1.2	1018.5 ± 0.6	6.7 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 14-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 14-3 is the 95 percent confidence interval for each parameter. Table 14-3 shows that average meteorological conditions on sample days near the Kentucky monitoring sites were generally representative of average weather conditions experienced throughout the year. The largest difference between the sample day average and the average for 2013 was calculated for the average maximum temperature for each site, the difference for which is largest for LAKY.

It should be noted that even though sample days are generally standardized, the need for making up invalid samples leads to additional sample days. This is why although the data are from the same weather station, the sample day averages are often different from each other, such as the case with ASKY, ASKY-M, and GLKY, for which the closest weather station is Tri-State/M.J. Ferguson Field Airport.

14.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations nearest the Kentucky sites, as presented in Section 14.2.2, were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 14-16 presents a map showing the distance between the Tri-State/M.J. Ferguson Field Airport weather station and ASKY, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 14-16 also presents three different wind roses for the ASKY monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

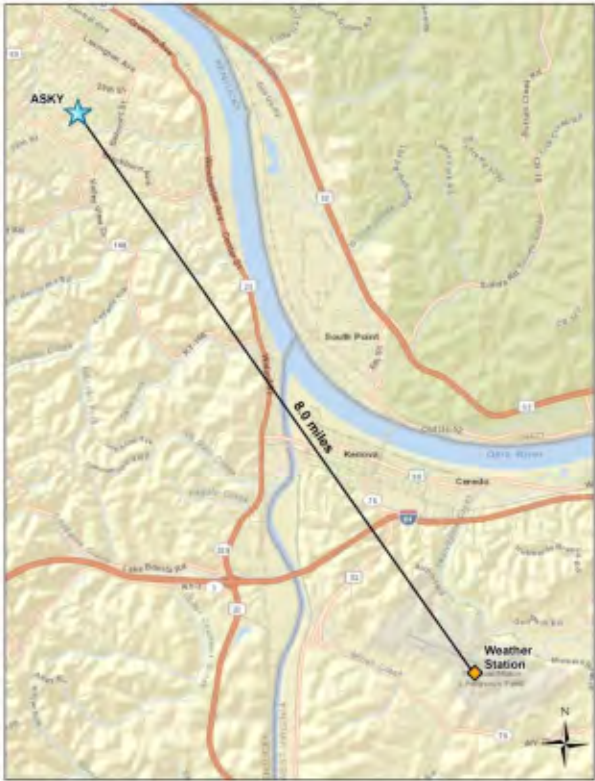
Figures 14-17 through 14-25 present the distance maps and wind roses for the remaining Kentucky monitoring sites.

Observations from Figures 14-16 through 14-18 for ASKY, ASKY-M, and GLKY, respectively, include the following:

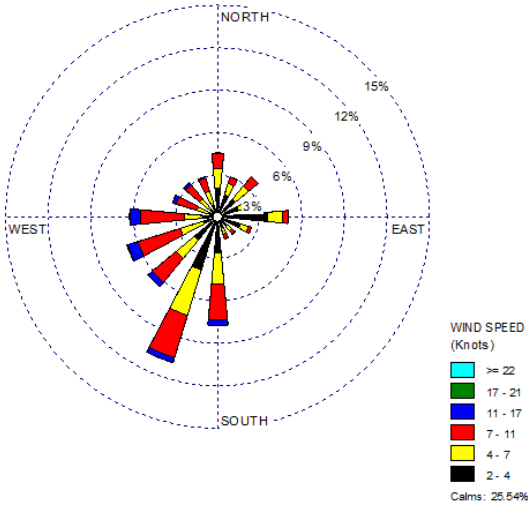
- The Tri-State/M.J. Ferguson Field weather station is the closest weather station to both Ashland sites and GLKY. The weather station is located between 8 miles and 9 miles southeast of the Ashland sites and 25 miles to the east-northeast of GLKY. This weather station is located in West Virginia, south of the Ohio River and east of the Big Sandy River.
- Because these three sites share the same weather station, the historical and full-year wind roses are identical across the sites.
- The historical wind rose shows that winds from the south, southwest quadrant, and west account for more than 40 percent of the wind observations near these sites, particularly those from south-southwest. Calm winds (those less than or equal to 2 knots) account for roughly one-quarter of the hourly measurements. Winds from the southeast quadrant were observed the least.
- The wind patterns on the full-year wind roses are similar to those on the historical wind roses.
- The sample day wind rose for ASKY resembles both the historical and full-year wind roses, although there is a slightly higher percentage of north-northwesterly winds as well as southwesterly and west-southwesterly winds. Conversely, the calm rate is slightly less.
- The sample day wind rose for ASKY-M has similar wind patterns as the sample day wind rose for ASKY.
- The sample day wind rose for GLKY has similar wind patterns as the sample day wind roses for ASKY and ASKY-M, although winds from the southwest to west account for an even higher percentage of winds on sample days while the percentage of winds from the south to south-southwest is slightly less.

Figure 14-16. Wind Roses for the Tri-State/M.J. Ferguson Field Airport Weather Station near ASKY

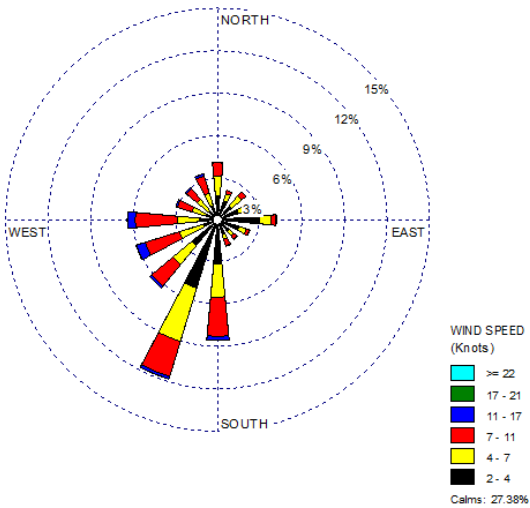
Location of ASKY and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

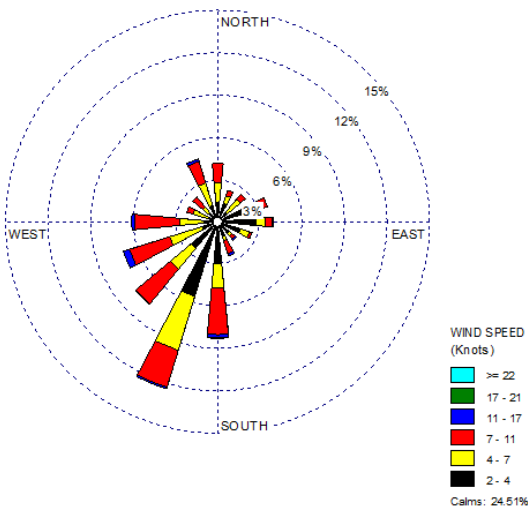
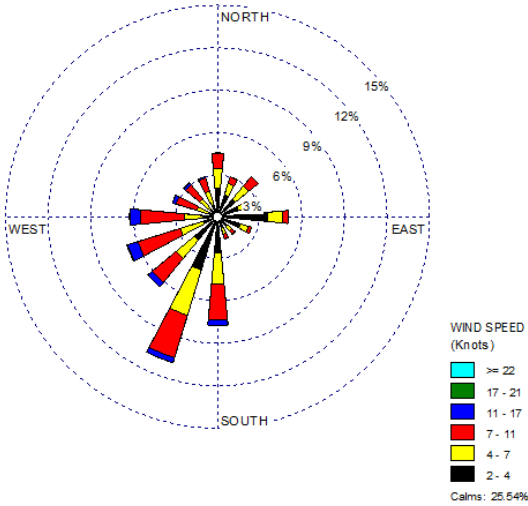


Figure 14-17. Wind Roses for the Tri-State/M.J. Ferguson Field Airport Weather Station near ASKY-M

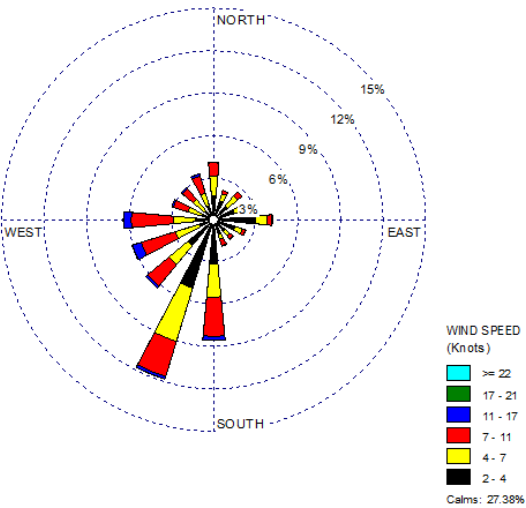
Location of ASKY-M and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

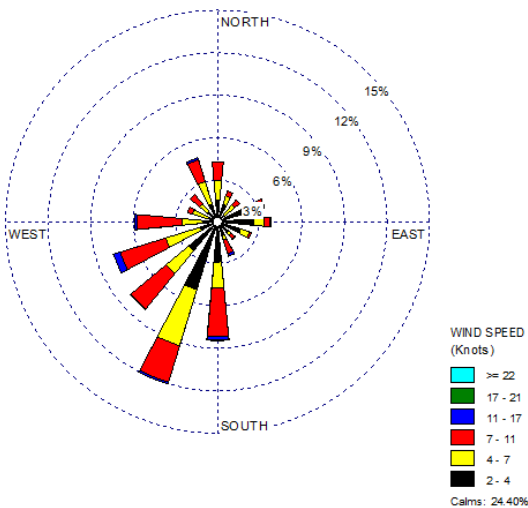
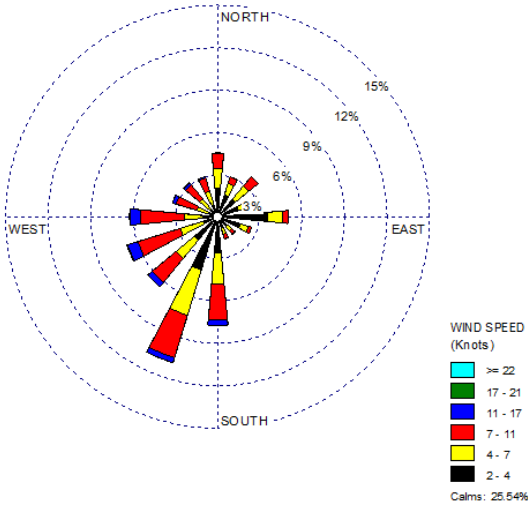


Figure 14-18. Wind Roses for the Tri-State/M.J. Ferguson Field Airport Weather Station near GLKY

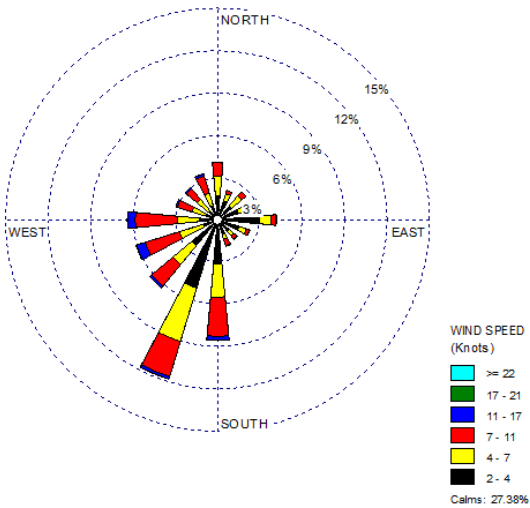
Location of GLKY and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

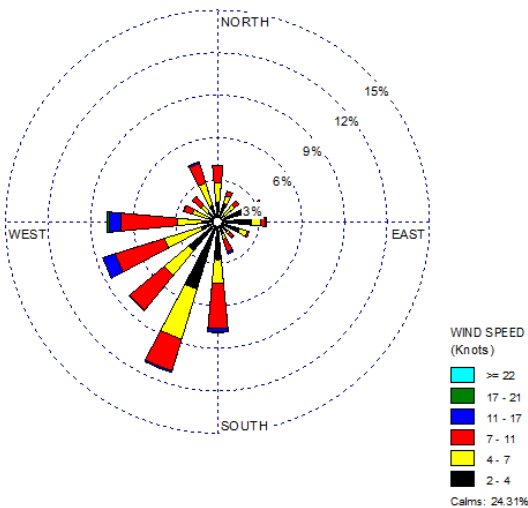
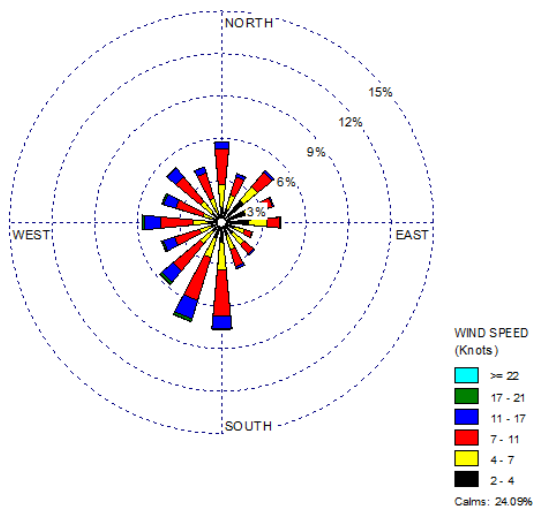


Figure 14-19. Wind Roses for the Evansville Regional Airport Weather Station near BAKY

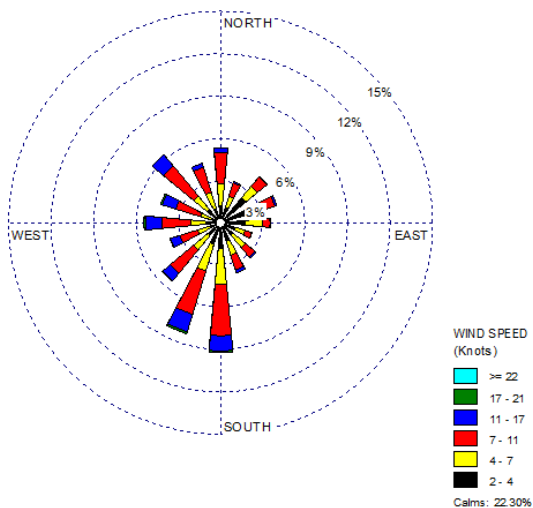
Location of BAKY and Weather Station



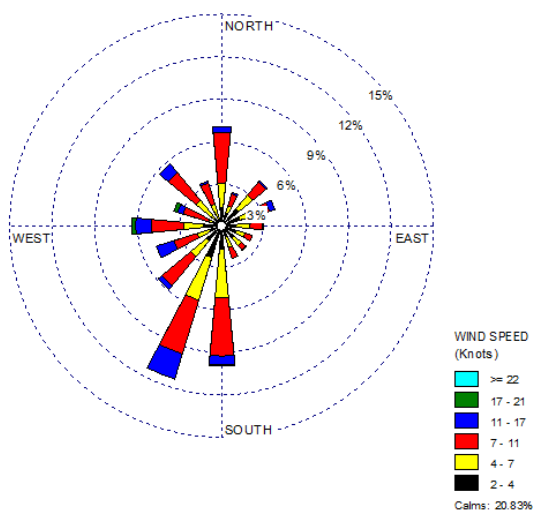
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 14-19 for BAKY include the following:

- The Evansville Regional Airport weather station is located approximately 12 miles north-northwest of BAKY. This weather station is in Ohio, with most of the city of Evansville between the site and the station.
- The historical wind rose shows that winds from a variety of directions were observed near BAKY, although winds from the south and southwest quadrant were observed the most and winds from the southeast quadrant were observed the least. Calm winds account for just less than one-quarter of the observations.
- The full-year wind rose shows that winds from all directions were observed, with winds from the south and south-southwest accounting for the highest percentage of winds greater than 2 knots and calm winds accounting for approximately 22 percent of the observations. Winds from the south, south-southwest, and northwest were observed slightly more often in 2013 compared to the historical wind rose.
- The sample day wind rose for BAKY shares some similarities with the full-year and historical wind roses, but exhibits some differences as well. Although southerly and south-southwesterly winds were still prevalent, the percentage of these winds was higher on sample days, as were most of the observations from the southwest quadrant. Northerly winds were also observed more often on sample days. Conversely, wind observations from the northwest and southeast quadrants were observed less frequently and calm winds accounted for one-fifth of the observations.

Figure 14-20. Wind Roses for the Barkley Regional Airport Weather Station near ATKY

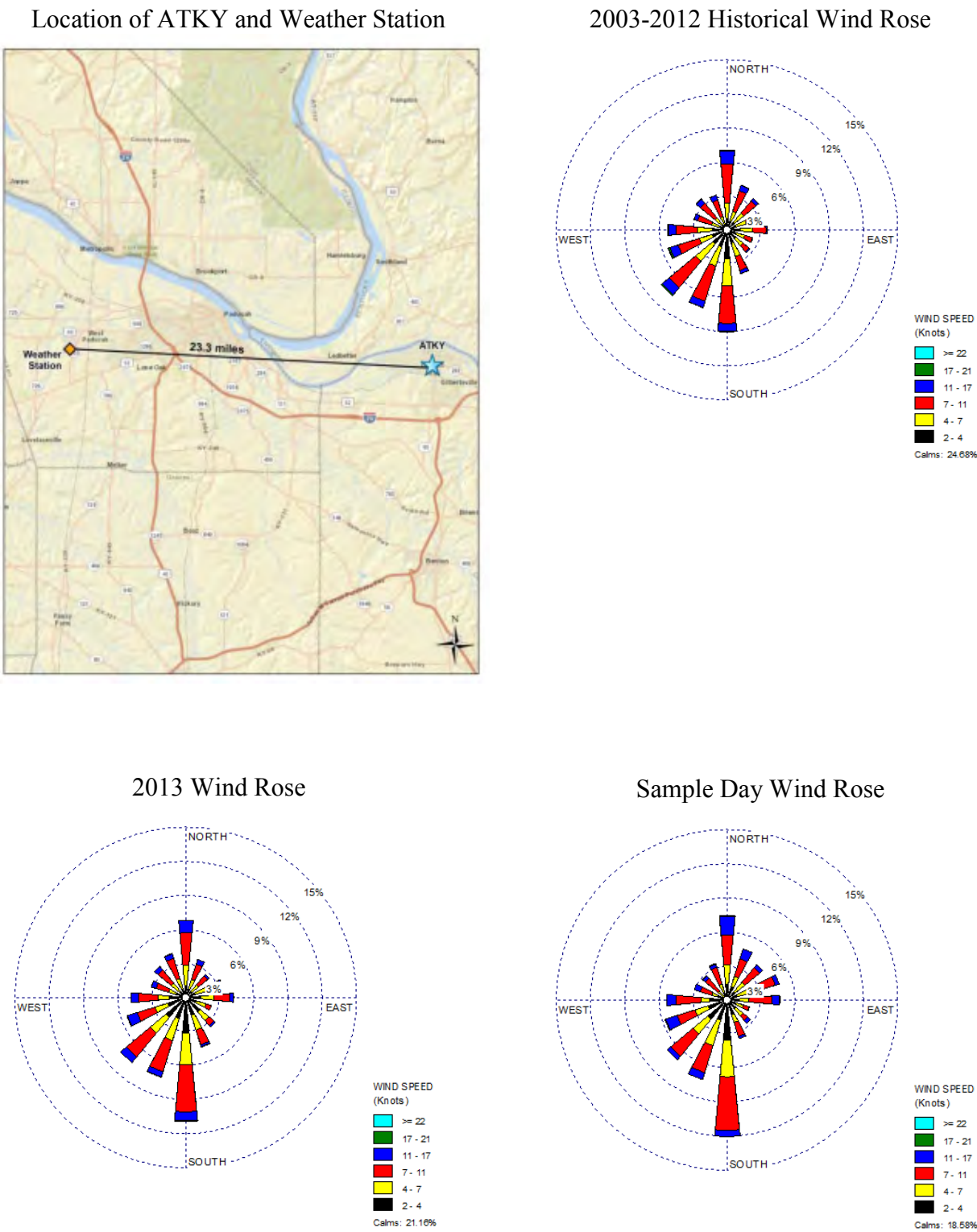


Figure 14-21. Wind Roses for the Barkley Regional Airport Weather Station near BLKY

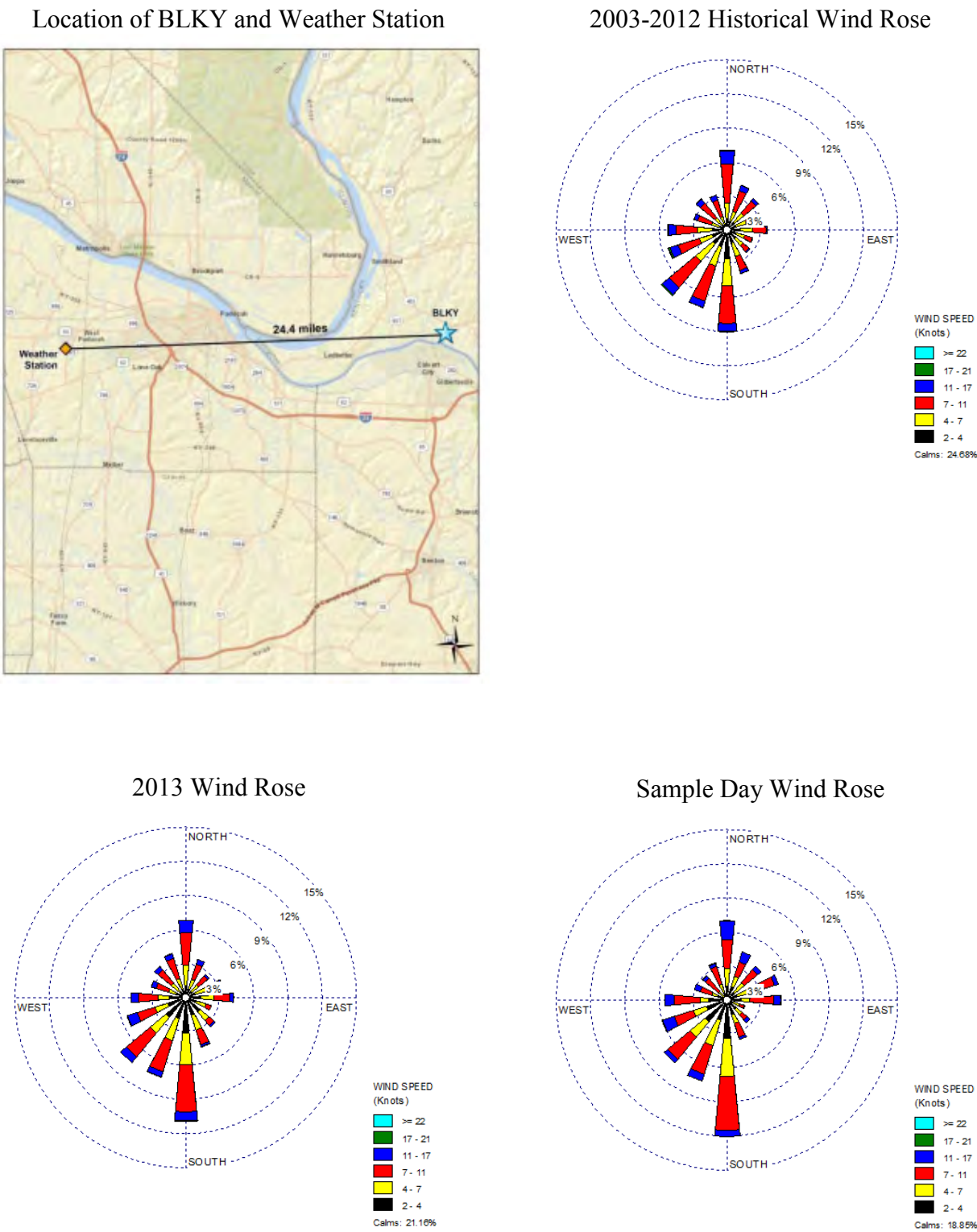
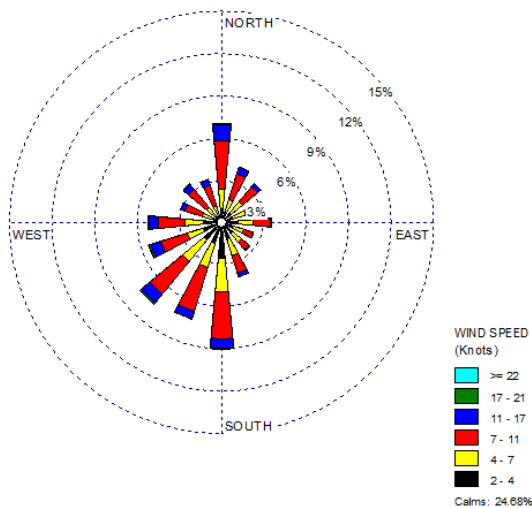


Figure 14-22. Wind Roses for the Barkley Regional Airport Weather Station near CCKY

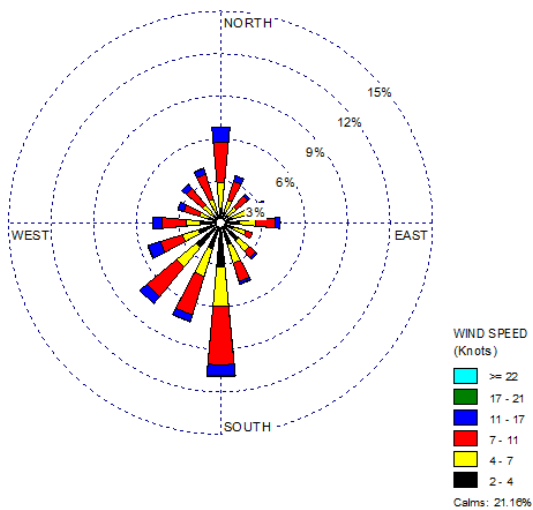
Location of CCKY and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

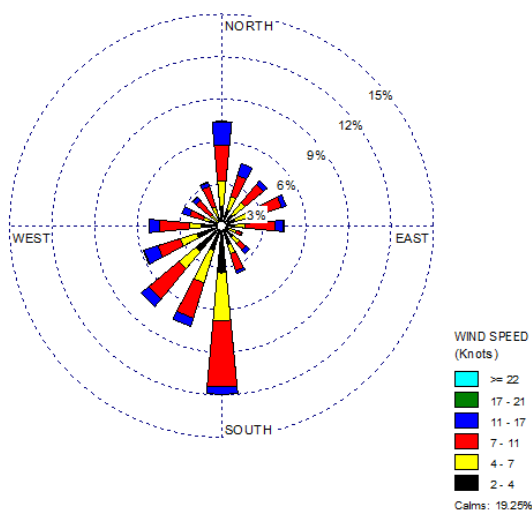


Figure 14-23. Wind Roses for the Barkley Regional Airport Weather Station near LAKY

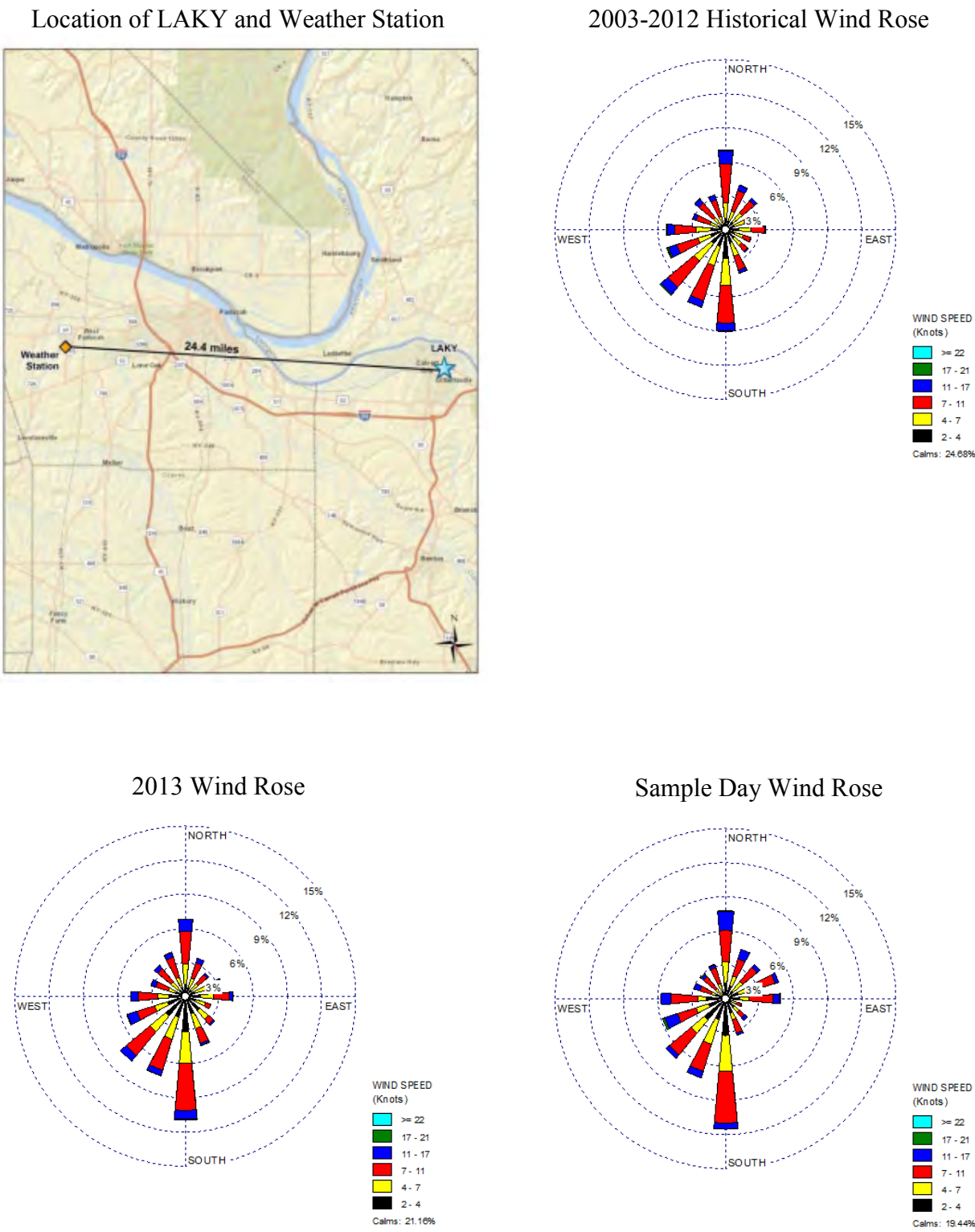
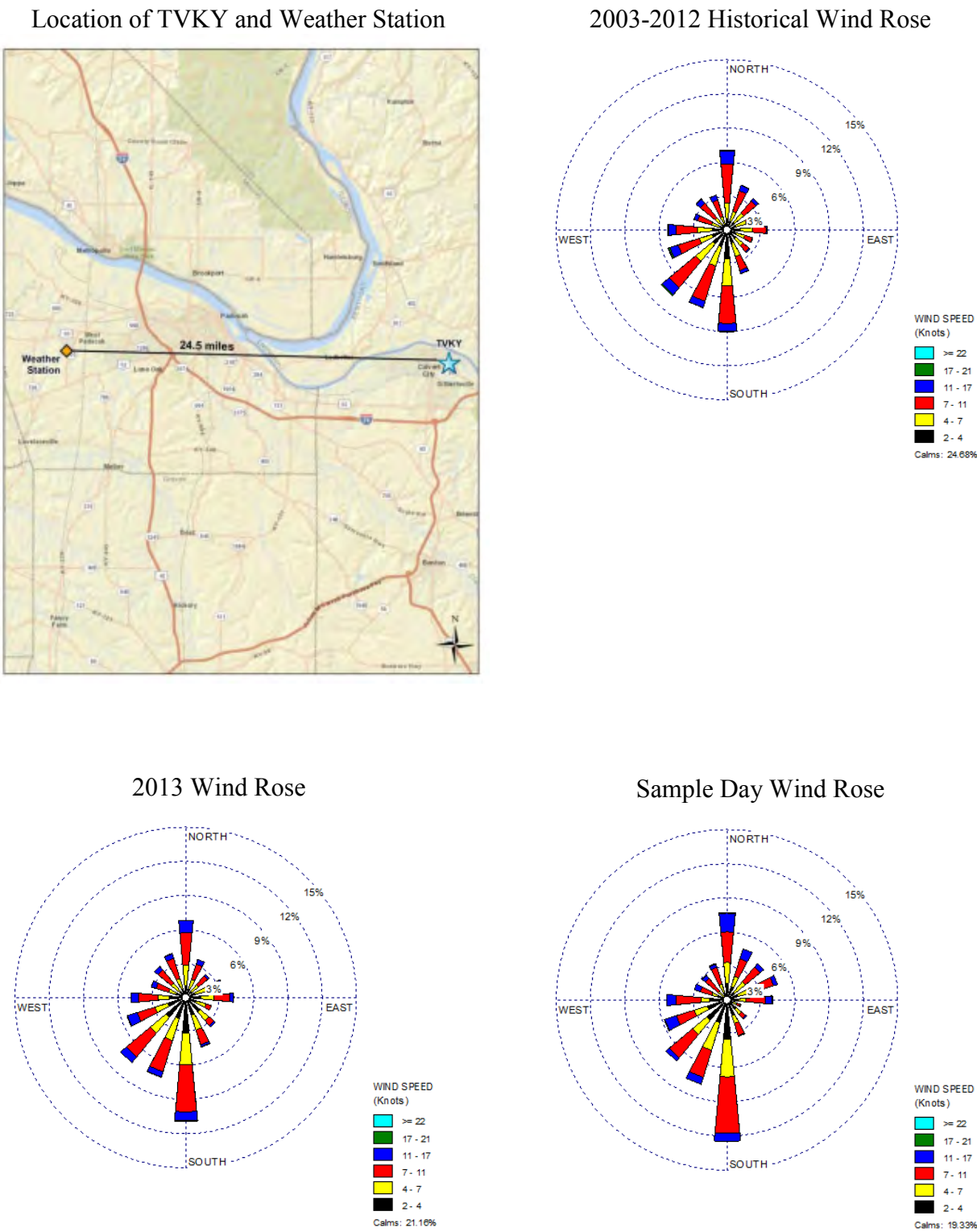


Figure 14-24. Wind Roses for the Barkley Regional Airport Weather Station near TVKY



Observations from Figures 14-20 through 14-24 for the Calvert City sites include the following:

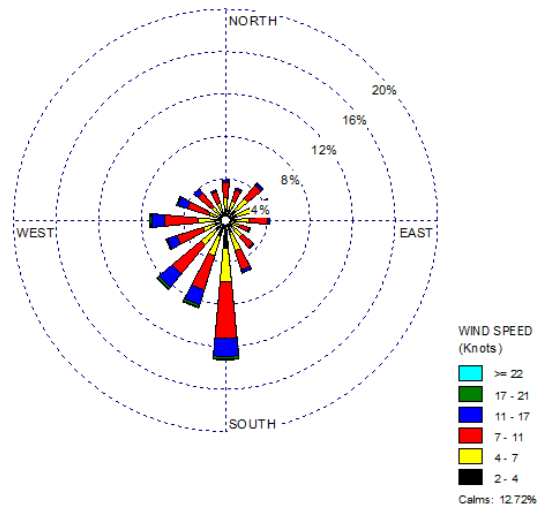
- The Barkley Regional Airport weather station is the closest weather station to all five sites in and near Calvert City. The weather station is located between 23 miles and 25 miles west of the Calvert City monitoring sites and just west of the Paducah metro area.
- The historical and full-year wind roses are identical across the Calvert City sites because these five sites share the same weather station.
- The historical wind rose shows that winds from the south, southwest quadrant, and north account for the majority of wind observations near these sites, although calm winds account for approximately 25 percent of the hourly measurements.
- The full-year wind roses resemble the historical wind roses, but with a higher percentage of southerly winds and fewer calm winds (21 percent).
- The sample day wind roses for the Calvert City sites resemble each other as well as the full-year and historical wind roses. The sample day wind roses show that southerly winds were prevalent on sample days near the Calvert City sites, with winds from the south, southwest quadrant and north accounting for the highest percentage of wind observations. Calm winds account for 19 percent to 20 percent of the wind observations on sample days.

Figure 14-25. Wind Roses for the Blue Grass Airport Weather Station near LEKY

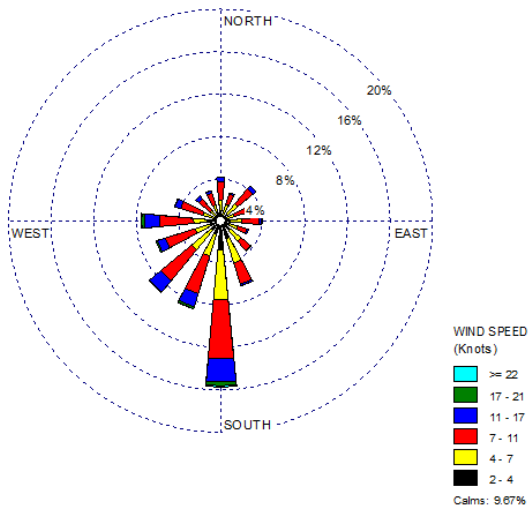
Location of LEKY and Weather Station



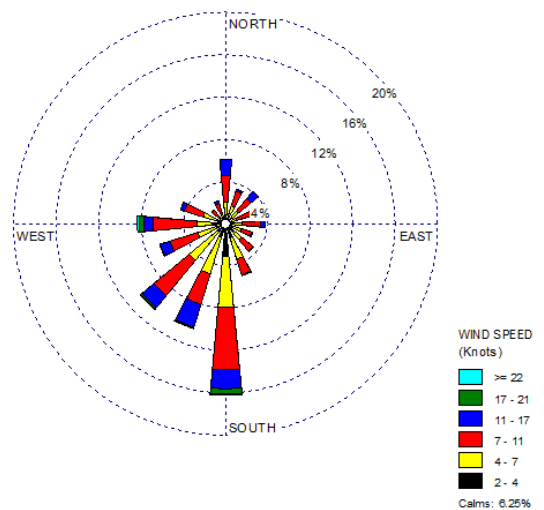
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 14-25 for LEKY include the following:

- The Blue Grass Airport weather station is located approximately 6 miles west-southwest of the LEKY monitoring site. As shown, the airport is located on the western edge of the Lexington metro area.
- The historical wind rose shows that winds from the south, southwest quadrant, and west account for the majority of wind observations near LEKY, particularly winds from the south, which account for roughly 13 percent of observations. Winds from other directions account for roughly 5 percent of wind observations or less each. Calm winds account for nearly 13 percent of the hourly measurements.
- The full-year wind rose resembles the historical wind rose, although a higher percentage of southerly winds were observed while the percentage of calm wind observations was less than 10 percent.
- The wind patterns on the sample day wind rose for LEKY resemble the wind patterns on full-year wind rose, with an even higher percentage of winds from the south to southwest and an even lower percentage of calm winds (6 percent).

14.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Kentucky monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens.

It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Table 14-4 provides an overview of which analyses were performed at each site. The site-specific results of the risk-based screening process are presented in Table 14-5, with the pollutants of interest for each site shaded in gray.

Table 14-4. Overview of Sampling Performed at the Kentucky Monitoring Sites

Site	VOCs	Carbonyl Compounds	PAHs	PM ₁₀ Metals	Hexavalent Chromium
ASKY	✓	✓	--	--	--
ASKY-M	--	--	--	✓	--
<i>GLKY</i>	✓	✓	✓	✓	✓
BAKY	--	--	--	✓	--
ATKY	✓	--	--	--	--
BLKY	✓	--	--	--	--
CCKY	✓	--	--	✓	--
LAKY	✓	--	--	--	--
TVKY	✓	--	--	--	--
LEKY	✓	✓	--	✓	--

-- = This pollutant group was not sampled for at this site.

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 14-4 include the following:

- Carbonyl compounds, VOCs, PAHs, PM₁₀ metals, and hexavalent chromium were sampled for at GLKY throughout 2013.
- Additional sites sampling PM₁₀ metals include ASKY-M, BAKY, CCKY, and LEKY.
- Additional sites sampling VOCs include ASKY, ATKY, BLKY, CCKY, LAKY, TVKY, and LEKY.
- Additional sites sampling carbonyl compounds include ASKY and LEKY.
- No additional sites sampled PAHs or hexavalent chromium.

Table 14-5. Risk-Based Screening Results for the Kentucky Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Health Department, Ashland, Kentucky - ASKY						
Acetaldehyde	0.45	61	61	100.00	16.90	16.90
Benzene	0.13	61	61	100.00	16.90	33.80
Carbon Tetrachloride	0.17	61	61	100.00	16.90	50.69
Formaldehyde	0.077	61	61	100.00	16.90	67.59
1,2-Dichloroethane	0.038	53	53	100.00	14.68	82.27
1,3-Butadiene	0.03	43	47	91.49	11.91	94.18
Hexachloro-1,3-butadiene	0.045	8	8	100.00	2.22	96.40
Ethylbenzene	0.4	7	61	11.48	1.94	98.34
<i>p</i> -Dichlorobenzene	0.091	5	27	18.52	1.39	99.72
Propionaldehyde	0.8	1	60	1.67	0.28	100.00
Total		361	500	72.20		
21st and Greenup, Ashland, Kentucky - ASKY-M						
Arsenic (PM ₁₀)	0.00023	53	59	89.83	50.96	50.96
Nickel (PM ₁₀)	0.0021	19	60	31.67	18.27	69.23
Manganese (PM ₁₀)	0.03	13	60	21.67	12.50	81.73
Lead (PM ₁₀)	0.015	10	60	16.67	9.62	91.35
Cadmium (PM ₁₀)	0.00056	9	60	15.00	8.65	100.00
Total		104	299	34.78		
Grayson, Kentucky - GLKY						
Benzene	0.13	61	61	100.00	15.14	15.14
Carbon Tetrachloride	0.17	61	61	100.00	15.14	30.27
Formaldehyde	0.077	61	61	100.00	15.14	45.41
1,2-Dichloroethane	0.038	56	56	100.00	13.90	59.31
Acetaldehyde	0.45	55	61	90.16	13.65	72.95
1,3-Butadiene	0.03	45	48	93.75	11.17	84.12
Arsenic	0.00023	44	58	75.86	10.92	95.04
Hexachloro-1,3-butadiene	0.045	12	13	92.31	2.98	98.01
Naphthalene	0.029	5	58	8.62	1.24	99.26
Cadmium	0.00056	1	59	1.69	0.25	99.50
Chloroprene	0.0021	1	1	100.00	0.25	99.75
1,2-Dibromoethane	0.0017	1	1	100.00	0.25	100.00
Total		403	538	74.91		
Baskett, Kentucky - BAKY						
Arsenic (PM ₁₀)	0.00023	53	59	89.83	98.15	98.15
Nickel (PM ₁₀)	0.0021	1	60	1.67	1.85	100.00
Total		54	119	45.38		

Table 14-5. Risk-Based Screening Results for the Kentucky Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Atmos Energy, Calvert City, Kentucky - ATKY						
Benzene	0.13	61	61	100.00	23.55	23.55
Carbon Tetrachloride	0.17	61	61	100.00	23.55	47.10
1,2-Dichloroethane	0.038	60	60	100.00	23.17	70.27
1,3-Butadiene	0.03	42	44	95.45	16.22	86.49
Vinyl chloride	0.11	24	38	63.16	9.27	95.75
Hexachloro-1,3-butadiene	0.045	8	9	88.89	3.09	98.84
1,1,2-Trichloroethane	0.0625	3	3	100.00	1.16	100.00
Total		259	276	93.84		
Smithland, Kentucky - BLKY						
Benzene	0.13	59	59	100.00	24.08	24.08
Carbon Tetrachloride	0.17	59	59	100.00	24.08	48.16
1,2-Dichloroethane	0.038	57	57	100.00	23.27	71.43
1,3-Butadiene	0.03	36	39	92.31	14.69	86.12
Vinyl chloride	0.11	16	35	45.71	6.53	92.65
Hexachloro-1,3-butadiene	0.045	7	8	87.50	2.86	95.51
1,1,2-Trichloroethane	0.0625	7	7	100.00	2.86	98.37
Chloroform	9.8	1	55	1.82	0.41	98.78
1,2-Dibromoethane	0.0017	1	1	100.00	0.41	99.18
<i>p</i> -Dichlorobenzene	0.091	1	10	10.00	0.41	99.59
1,1-Dichloroethane	0.625	1	7	14.29	0.41	100.00
Total		245	337	72.70		
Calvert City Elementary School, Calvert City, Kentucky - CCKY						
Benzene	0.13	61	61	100.00	21.71	21.71
Carbon Tetrachloride	0.17	61	61	100.00	21.71	43.42
1,2-Dichloroethane	0.038	59	59	100.00	21.00	64.41
Arsenic (PM ₁₀)	0.00023	42	55	76.36	14.95	79.36
1,3-Butadiene	0.03	40	45	88.89	14.23	93.59
Hexachloro-1,3-butadiene	0.045	10	11	90.91	3.56	97.15
Vinyl chloride	0.11	6	26	23.08	2.14	99.29
Nickel (PM ₁₀)	0.0021	1	56	1.79	0.36	99.64
1,1,2-Trichloroethane	0.0625	1	1	100.00	0.36	100.00
Total		281	375	74.93		

Table 14-5. Risk-Based Screening Results for the Kentucky Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Lazy Daze, Calvert City, Kentucky - LAKY						
Benzene	0.13	60	60	100.00	23.35	23.35
Carbon Tetrachloride	0.17	60	60	100.00	23.35	46.69
1,2-Dichloroethane	0.038	60	60	100.00	23.35	70.04
1,3-Butadiene	0.03	47	48	97.92	18.29	88.33
Vinyl chloride	0.11	14	29	48.28	5.45	93.77
Hexachloro-1,3-butadiene	0.045	11	12	91.67	4.28	98.05
1,1,2-Trichloroethane	0.0625	3	5	60.00	1.17	99.22
1,2-Dibromoethane	0.0017	1	1	100.00	0.39	99.61
Ethylbenzene	0.4	1	60	1.67	0.39	100.00
Total		257	335	76.72		
TVA Substation, Calvert City, Kentucky - TVKY						
Benzene	0.13	61	61	100.00	21.63	21.63
Carbon Tetrachloride	0.17	61	61	100.00	21.63	43.26
1,2-Dichloroethane	0.038	61	61	100.00	21.63	64.89
1,3-Butadiene	0.03	45	46	97.83	15.96	80.85
Vinyl chloride	0.11	22	36	61.11	7.80	88.65
Hexachloro-1,3-butadiene	0.045	11	11	100.00	3.90	92.55
<i>p</i> -Dichlorobenzene	0.091	7	24	29.17	2.48	95.04
1,1,2-Trichloroethane	0.0625	7	9	77.78	2.48	97.52
1,2-Dibromoethane	0.0017	3	3	100.00	1.06	98.58
Trichloroethylene	0.2	2	12	16.67	0.71	99.29
1,1-Dichloroethane	0.625	1	11	9.09	0.35	99.65
Ethylbenzene	0.4	1	61	1.64	0.35	100.00
Total		282	396	71.21		

Table 14-5. Risk-Based Screening Results for the Kentucky Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Lexington, Kentucky - LEKY						
Acetaldehyde	0.45	61	61	100.00	16.90	16.90
Formaldehyde	0.077	61	61	100.00	16.90	33.80
Arsenic (PM ₁₀)	0.00023	46	52	88.46	12.74	46.54
Benzene	0.13	45	45	100.00	12.47	59.00
Carbon Tetrachloride	0.17	45	45	100.00	12.47	71.47
1,2-Dichloroethane	0.038	43	43	100.00	11.91	83.38
1,3-Butadiene	0.03	40	41	97.56	11.08	94.46
Hexachloro-1,3-butadiene	0.045	9	9	100.00	2.49	96.95
Ethylbenzene	0.4	4	45	8.89	1.11	98.06
<i>p</i> -Dichlorobenzene	0.091	3	28	10.71	0.83	98.89
Nickel (PM ₁₀)	0.0021	3	52	5.77	0.83	99.72
Manganese (PM ₁₀)	0.03	1	53	1.89	0.28	100.00
Total		361	535	67.48		

Observations for the Ashland sites from Table 14-5 include the following:

- The number of pollutants failing screens varied significantly among the monitoring sites; this is expected given the different pollutants measured at each site, as shown in Table 14-4. VOCs and carbonyl compounds were sampled for at ASKY while only PM₁₀ metals were sampled for at ASKY-M.
- Ten pollutants failed at least one screen for ASKY, with 72 percent of concentrations for these 10 pollutants greater than their associated risk screening value (or failed screens).
- Seven pollutants contributed to 95 percent of failed screens for ASKY and therefore were identified as pollutants of interest. These seven include two carbonyl compounds and five VOCs.
- Five metals failed at least one screen for ASKY-M, with 35 percent of concentrations for these five pollutants greater than their associated risk screening value (or failed screens).
- All five metals contributed to 95 percent of failed screens for ASKY-M and therefore were identified as pollutants of interest. ASKY-M is one of only two NMP sites with manganese as a pollutant of interest (TOOK is the other). This is also true for lead and cadmium (S4MO is the other).

Observations for GLKY from Table 14-5 include the following:

- GLKY sampled for all five pollutant groups shown in Table 14-4.
- Twelve pollutants failed at least one screen for GLKY, with nearly 75 percent of concentrations for these 12 pollutants greater than their associated risk screening value (or failed screens).
- Seven pollutants contributed to 95 percent of failed screens for GLKY and therefore were identified as pollutants of interest. These include two carbonyl compounds, four VOCs, and one metal.

Observations for BAKY from Table 14-5 include the following:

- Like ASKY-M, BAKY sampled for PM₁₀ metals only.
- Arsenic and nickel failed at least one screen for BAKY, with 45 percent of concentrations for these two pollutants greater than their associated risk screening value (or failed screens).
- Arsenic contributed to 98 percent of the failed screens for BAKY and therefore was identified as BAKY's sole pollutant of interest.

Observations for the Calvert City sites from Table 14-5 include the following:

- VOCs were sampled for at all five Calvert City sites. PM₁₀ metals were also sampled for at CCKY.
- The number of pollutants whose concentrations were greater than their associated risk screening value varied from seven (ATKY) to 12 (TVKY).
- Five pollutants contributed to 95 percent of failed screens for ATKY and therefore were identified as pollutants of interest for this site.
- Seven pollutants contributed to 95 percent of failed screens for BLKY and therefore were identified as pollutants of interest for this site. Although the pollutants through hexachloro-1,3-butadiene together account for more than 95 percent of the total failed screens for BLKY, 1,1,2-trichloroethane failed the same number of screens as hexachloro-1,3-butadiene; thus, 1,1,2-trichloroethane was added as a pollutant of interest for BLKY, per the procedure described in Section 3.2.
- Six pollutants contributed to 95 percent of failed screens for CCKY and therefore were identified as pollutants of interest for this site. The pollutants of interest for CCKY include one speciated metal and five VOCs.
- Six pollutants contributed to 95 percent of failed screens for LAKY and therefore were identified as pollutants of interest for this site.

- Eight pollutants contributed to 95 percent of failed screens for TVKY and therefore were identified as pollutants of interest for this site. Similar to BLKY, 1,1,2-trichloroethane was added as pollutants of interest for TVKY as this pollutant failed the same number of screens as *p*-dichlorobenzene, which is the first pollutant to reach the 95 percent contribution level.
- Benzene, carbon tetrachloride, 1,2-dichloroethane, and 1,3-butadiene were identified as pollutants of interest for all five Calvert City sites. Vinyl chloride was identified as a pollutant of interest for four of the five sites (CCKY was the exception), as was hexachloro-1,3-butadiene (ATKY was the exception). ATKY, BLKY, LAKY, and TVKY are the only NMP sites with vinyl chloride as a pollutant of interest.

Observations for LEKY from Table 14-5 include the following:

- Aside from GLKY, LEKY sampled for the most pollutant groups. Carbonyl compounds, VOCs, and PM₁₀ metals were sampled for at LEKY.
- Twelve pollutants failed at least one screen for LEKY, with 67 percent of concentrations for these 12 pollutants greater than their associated risk screening value (or failed screens).
- Eight pollutants contributed to 95 percent of failed screens for LEKY and therefore were identified as pollutants of interest. These include two carbonyl compounds, five VOCs, and one metal.

14.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Kentucky monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at the Kentucky monitoring sites are provided in Appendices J, L, M, N, and O.

14.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Kentucky sites, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Kentucky monitoring sites are presented in Table 14-6, where applicable. Note that concentrations of the PAHs and metals are presented in ng/m³ for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 14-6. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Kentucky Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
Health Department, Ashland, Kentucky - ASKY						
Acetaldehyde	61/61	1.04 ± 0.19	1.69 ± 0.43	1.04 ± 0.14	1.00 ± 0.17	1.19 ± 0.14
Benzene	61/61	0.86 ± 0.12	0.71 ± 0.32	1.03 ± 0.42	3.36 ± 5.50	1.52 ± 1.39
1,3-Butadiene	47/61	0.06 ± 0.03	0.04 ± 0.02	0.05 ± 0.02	0.08 ± 0.03	0.06 ± 0.01
Carbon Tetrachloride	61/61	0.65 ± 0.04	0.69 ± 0.06	0.66 ± 0.04	0.62 ± 0.03	0.65 ± 0.02
1,2-Dichloroethane	53/61	0.09 ± 0.01	0.09 ± 0.02	0.04 ± 0.02	0.08 ± 0.01	0.08 ± 0.01
Formaldehyde	61/61	1.42 ± 0.30	3.57 ± 1.04	2.98 ± 0.49	1.29 ± 0.22	2.30 ± 0.38

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m³ for ease of viewing.

Table 14-6. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Kentucky Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
21st and Greenup, Ashland, Kentucky - ASKY-M						
Arsenic (PM ₁₀) ^a	59/60	1.08 ± 0.65	1.46 ± 0.46	1.39 ± 0.48	1.04 ± 0.77	1.24 ± 0.29
Cadmium (PM ₁₀) ^a	60/60	0.60 ± 0.72	0.28 ± 0.10	0.37 ± 0.23	0.36 ± 0.30	0.40 ± 0.19
Lead (PM ₁₀) ^a	60/60	8.21 ± 5.82	9.37 ± 3.31	9.24 ± 3.18	6.32 ± 3.38	8.25 ± 1.89
Manganese (PM ₁₀) ^a	60/60	18.53 ± 9.94	26.42 ± 9.60	21.51 ± 6.17	13.32 ± 6.96	19.86 ± 4.06
Nickel (PM ₁₀) ^a	60/60	2.61 ± 3.02	2.29 ± 0.76	2.45 ± 0.85	2.27 ± 2.15	2.40 ± 0.89
Grayson, Kentucky - GLKY						
Acetaldehyde	61/61	0.62 ± 0.13	0.94 ± 0.15	0.56 ± 0.06	0.62 ± 0.09	0.68 ± 0.06
Benzene	61/61	0.70 ± 0.16	0.33 ± 0.05	0.55 ± 0.35	0.38 ± 0.06	0.49 ± 0.10
1,3-Butadiene	48/61	0.06 ± 0.01	0.03 ± 0.02	0.03 ± 0.01	0.04 ± 0.01	0.04 ± 0.01
Carbon Tetrachloride	61/61	0.65 ± 0.05	0.72 ± 0.07	0.70 ± 0.04	0.59 ± 0.05	0.67 ± 0.03
1,2-Dichloroethane	56/61	0.09 ± 0.01	0.10 ± 0.01	0.05 ± 0.02	0.06 ± 0.01	0.08 ± 0.01
Formaldehyde	61/61	0.80 ± 0.18	2.08 ± 0.44	1.67 ± 0.26	0.73 ± 0.15	1.31 ± 0.20
Arsenic (PM ₁₀) ^a	58/59	0.50 ± 0.30	0.59 ± 0.16	0.57 ± 0.17	0.30 ± 0.13	0.48 ± 0.10
Baskett, Kentucky - BAKY						
Arsenic (PM ₁₀) ^a	59/60	0.68 ± 0.22	0.89 ± 0.30	1.24 ± 0.80	0.48 ± 0.18	0.82 ± 0.22
Nickel (PM ₁₀) ^a	60/60	0.47 ± 0.19	0.74 ± 0.29	0.74 ± 0.51	0.48 ± 0.18	0.61 ± 0.15
Atmos Energy, Calvert City, Kentucky - ATKY						
Benzene	61/61	0.75 ± 0.10	0.42 ± 0.09	0.48 ± 0.09	0.49 ± 0.08	0.54 ± 0.05
1,3-Butadiene	44/61	0.06 ± 0.04	0.08 ± 0.09	0.05 ± 0.02	0.07 ± 0.03	0.07 ± 0.02
Carbon Tetrachloride	61/61	0.65 ± 0.02	0.72 ± 0.06	0.69 ± 0.03	0.63 ± 0.04	0.67 ± 0.02
1,2-Dichloroethane	60/61	0.33 ± 0.25	0.28 ± 0.20	0.36 ± 0.22	0.22 ± 0.13	0.30 ± 0.10
Vinyl chloride	38/61	0.99 ± 0.79	0.48 ± 0.54	0.50 ± 0.58	0.42 ± 0.62	0.60 ± 0.31

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m³ for ease of viewing.

Table 14-6. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Kentucky Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Smithland, Kentucky - BLKY						
Benzene	59/59	0.63 ± 0.13	0.78 ± 0.31	0.66 ± 0.35	0.63 ± 0.39	0.67 ± 0.15
1,3-Butadiene	39/59	0.03 ± 0.02	2.05 ± 1.82	0.13 ± 0.16	0.29 ± 0.32	0.63 ± 0.49
Carbon Tetrachloride	59/59	2.21 ± 3.16	0.76 ± 0.07	0.82 ± 0.13	0.65 ± 0.03	1.11 ± 0.77
1,2-Dichloroethane	57/59	1.16 ± 2.11	2.03 ± 1.89	0.95 ± 0.74	0.94 ± 1.06	1.27 ± 0.75
Hexachloro-1,3-butadiene	8/59	0.02 ± 0.03	0.01 ± 0.02	<0.01 ± 0.01	0.04 ± 0.05	0.02 ± 0.01
1,1,2-Trichloroethane	7/59	0.01 ± 0.01	0.01 ± 0.02	0.05 ± 0.06	0 ± 0.06	0.02 ± 0.02
Vinyl chloride	35/59	0.10 ± 0.17	0.10 ± 0.06	0.10 ± 0.05	0.43 ± 0.67	0.18 ± 0.16
Calvert City Elementary School, Calvert City, Kentucky - CCKY						
Benzene	61/61	0.67 ± 0.09	0.37 ± 0.05	0.46 ± 0.09	0.48 ± 0.11	0.50 ± 0.05
1,3-Butadiene	45/61	0.04 ± 0.02	0.06 ± 0.04	0.06 ± 0.03	0.85 ± 1.58	0.26 ± 0.40
Carbon Tetrachloride	61/61	0.64 ± 0.03	0.72 ± 0.05	0.69 ± 0.06	0.64 ± 0.04	0.67 ± 0.02
1,2-Dichloroethane	59/61	0.17 ± 0.06	0.24 ± 0.23	0.30 ± 0.22	0.25 ± 0.11	0.24 ± 0.08
Hexachloro-1,3-butadiene	11/61	0.01 ± 0.01	0 ± 0.01	0.02 ± 0.02	0.03 ± 0.03	0.02 ± 0.01
Arsenic (PM_{10}) ^a	55/56	0.52 ± 0.18	0.64 ± 0.21	0.76 ± 0.32	0.54 ± 0.41	0.61 ± 0.15
Lazy Daze, Calvert City, Kentucky - LAKY						
Benzene	60/60	0.73 ± 0.18	0.52 ± 0.16	0.53 ± 0.14	0.73 ± 0.37	0.62 ± 0.11
1,3-Butadiene	48/60	0.07 ± 0.05	0.88 ± 1.57	0.05 ± 0.02	1.57 ± 2.86	0.66 ± 0.80
Carbon Tetrachloride	60/60	0.65 ± 0.04	0.70 ± 0.10	0.69 ± 0.05	0.67 ± 0.04	0.68 ± 0.03
1,2-Dichloroethane	60/60	0.23 ± 0.14	0.39 ± 0.31	0.55 ± 0.50	1.62 ± 1.73	0.70 ± 0.45
Hexachloro-1,3-butadiene	12/60	0.03 ± 0.03	<0.01 ± 0.01	0.02 ± 0.02	0.03 ± 0.03	0.02 ± 0.01
Vinyl chloride	29/60	0.09 ± 0.13	0.04 ± 0.04	0.05 ± 0.05	0.09 ± 0.06	0.07 ± 0.04

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Table 14-6. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Kentucky Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
TVA Substation, Calvert City, Kentucky - TVKY						
Benzene	61/61	0.93 ± 0.39	0.65 ± 0.59	0.88 ± 0.56	1.74 ± 0.88	1.06 ± 0.32
1,3-Butadiene	46/61	0.09 ± 0.08	1.72 ± 2.84	0.17 ± 0.13	2.08 ± 2.72	1.03 ± 0.97
Carbon Tetrachloride	61/61	0.85 ± 0.23	0.77 ± 0.09	0.83 ± 0.20	0.76 ± 0.11	0.80 ± 0.08
<i>p</i> -Dichlorobenzene	24/61	<0.01 ± 0.01	0.01 ± 0.01	0.08 ± 0.06	0.03 ± 0.02	0.03 ± 0.02
1,2-Dichloroethane	61/61	2.69 ± 3.05	0.88 ± 0.88	1.29 ± 1.86	9.73 ± 13.97	3.75 ± 3.68
Hexachloro-1,3-butadiene	11/61	<0.01 ± 0.01	0.01 ± 0.02	0.02 ± 0.02	0.02 ± 0.01	0.01 ± 0.01
1,1,2-Trichloroethane	9/61	0.01 ± 0.02	0 ± 0.02	0.03 ± 0.04	0.16 ± 0.27	0.05 ± 0.07
Vinyl chloride	36/61	0.54 ± 0.82	0.10 ± 0.11	0.10 ± 0.13	0.41 ± 0.40	0.29 ± 0.22
Lexington, Kentucky - LEKY						
Acetaldehyde	61/61	0.87 ± 0.12	1.51 ± 0.30	1.68 ± 0.19	1.87 ± 0.30	1.49 ± 0.15
Benzene	45/45	NA	NA	0.50 ± 0.07	0.81 ± 0.16	NA
1,3-Butadiene	41/45	NA	NA	0.06 ± 0.02	0.08 ± 0.02	NA
Carbon Tetrachloride	45/45	NA	NA	0.66 ± 0.04	0.63 ± 0.06	NA
1,2-Dichloroethane	43/45	NA	NA	0.05 ± 0.01	0.09 ± 0.01	NA
Formaldehyde	61/61	1.59 ± 0.30	3.94 ± 1.05	4.65 ± 0.77	1.56 ± 0.52	2.91 ± 0.49
Hexachloro-1,3-butadiene	9/45	NA	NA	<0.01 ± 0.01	0.04 ± 0.03	NA
Arsenic (PM ₁₀) ^a	52/53	0.52 ± 0.19	0.75 ± 0.15	0.77 ± 0.25	0.67 ± 0.33	0.68 ± 0.12

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m³ for ease of viewing.

Observations for the Ashland sites from Table 14-6 include the following:

- VOCs and carbonyl compounds were sampled for at ASKY and PM₁₀ metals were sampled for at ASKY-M. Thus, these sites have no pollutants of interest in common.
- With the exception of 1,3-butadiene and 1,2-dichloroethane, each of the pollutants of interest for ASKY was detected in all the valid VOC samples collected.

- The pollutants of interest with the highest annual average concentrations for ASKY are formaldehyde ($2.30 \pm 0.38 \mu\text{g}/\text{m}^3$), benzene ($1.52 \pm 1.39 \mu\text{g}/\text{m}^3$), and acetaldehyde ($1.19 \pm 0.14 \mu\text{g}/\text{m}^3$). Note the high confidence interval for the annual average concentration of benzene.
- The second quarter average concentration of acetaldehyde is significantly higher than the other quarterly averages and has a relatively large confidence interval associated with it. A review of the data shows that the maximum acetaldehyde concentration was measured at ASKY on June 21, 2013 ($4.08 \mu\text{g}/\text{m}^3$) and is the only acetaldehyde concentration greater than $2.5 \mu\text{g}/\text{m}^3$ measured at this site. The six highest acetaldehyde concentrations measured at ASKY were all measured between April and June, with the seventh and eighth highest measured at the end of March.
- The second quarter average concentration of formaldehyde is also the highest of the quarterly averages for ASKY, although the third quarter average is also relatively high. The maximum formaldehyde concentration was also measured on June 21, 2013 at ASKY ($9.05 \mu\text{g}/\text{m}^3$). All but three of the 29 formaldehyde concentrations greater than $2 \mu\text{g}/\text{m}^3$ were measured at ASKY during the second and third quarters of 2013 (with two of the three measured at the end of March, and the third in October). Conversely, the 14 lowest formaldehyde concentrations were all measured during the first or fourth quarters of 2013.
- The fourth quarter average benzene concentration is more than three times greater than the other quarterly averages and has a confidence interval greater than the average itself. This indicates that outliers may be affecting this quarterly average. A review of the data shows that the maximum benzene concentration was measured at ASKY on November 6, 2013 ($43.5 \mu\text{g}/\text{m}^3$). This measurement is nearly 14 times greater than the next highest benzene concentrations measured at this site ($3.19 \mu\text{g}/\text{m}^3$) and nearly five times greater than the next highest benzene concentration measured across the program ($9.38 \mu\text{g}/\text{m}^3$ measured at OCOK). All other benzene concentrations measured at ASKY during the fourth quarter are less than $1.5 \mu\text{g}/\text{m}^3$, explaining the large confidence interval associated with this quarterly average.
- Table 4-9 presents the NMP sites with the 10 highest annual average concentrations for each of the program-level VOC pollutants of interest. This table shows that ASKY has the fourth highest annual average concentration of benzene calculated across the program. However, this site has the largest confidence interval among the sites shown (at least four or more times greater), indicating that this annual average is influenced by outliers while the other annual averages likely run higher on a more consistent basis. Excluding the maximum concentration from the calculation would result in an annual average concentration for ASKY nearly half as high and in the middle of the site-specific annual average concentrations of benzene.
- With the exception of arsenic, the metal pollutants of interest were detected in all of the valid samples collected at ASKY-M. Arsenic was detected in all but one of samples collected.

- The pollutant of interest with the highest annual average concentration for ASKY-M is manganese ($19.86 \pm 4.06 \text{ ng/m}^3$), followed by lead ($8.25 \pm 1.89 \text{ ng/m}^3$), and nickel ($2.40 \pm 0.89 \text{ ng/m}^3$).
- Many of the quarterly average concentrations for the pollutants of interest for ASKY-M have relatively large confidence intervals, particularly for the first quarter of 2013, indicating the measurements collected at ASKY-M are highly variable. For instance, concentrations of nickel span two orders of magnitude, ranging from 0.200 ng/m^3 to 21.2 ng/m^3 , with a median concentration of 1.46 ng/m^3 , nearly 1 ng/m^3 less than the annual average concentration. Both the maximum and minimum nickel concentrations measured at ASKY-M were measured during the first quarter of 2013. The maximum concentration of nickel measured at ASKY-M is the maximum nickel concentration measured across the program. This explains why the confidence interval for the first quarter is greater than the average itself. The second highest nickel concentration across the program was also measured at ASKY-M (17.1 ng/m^3) and was measured on November 30, 2013. The second highest and second lowest nickel concentrations were measured at ASKY-M during the fourth quarter of 2013, which explains the relatively large confidence interval shown in Table 14-6 for this pollutant.
- Concentrations of manganese measured at ASKY-M range from 1.46 ng/m^3 to 56.0 ng/m^3 , with a median concentration of 15.59 ng/m^3 . Five measurements greater than 50 ng/m^3 were measured at ASKY-M in 2013, the most of any other NMP site sampling PM_{10} metals. Three of these five were measured on back-to-back sample days in April 2013. At least four manganese measurements greater than 25 ng/m^3 were measured at ASKY-M in each quarter of 2013 while at least one manganese concentration less than 5 ng/m^3 was also measured in each quarter. This explains the relatively large confidence intervals shown for each quarterly average of manganese in Table 14-6.
- Concentrations of lead measured at ASKY-M range from 0.94 ng/m^3 to 40.5 ng/m^3 , with a median concentration of 5.53 ng/m^3 . The first quarter average concentration, while not the highest quarterly average, has the largest confidence interval associated with it. The maximum concentration of lead was measured at ASKY-M on March 23, 2013 and is nearly three times greater than the next highest lead concentration measured during the first quarter of 2013 at this site. The maximum concentration of lead measured at ASKY-M is the second highest lead measurement across the program. ASKY-M has the second highest number of lead measurements greater than 15 ng/m^3 (10), second only to S4MO.
- The first quarter average concentration of cadmium is greater than the other quarterly averages and the associated confidence interval is greater than the average itself. Although this indicates the likely presence of outliers factoring into the average concentration, the confidence intervals for each of the quarterly averages are relatively large. Concentrations of cadmium measured at ASKY-M range from 0.040 ng/m^3 to 5.05 ng/m^3 , with a median concentration of 0.19 ng/m^3 . The maximum cadmium concentration was measured at ASKY-M on the same day the maximum lead concentration was measured and is the second highest cadmium concentration

measured across the program. Both the maximum and minimum cadmium concentrations were measured at ASKY-M during the first quarter of 2013. Three cadmium concentrations greater than 1 ng/m³ were measured at ASKY-M and are spread across the calendar quarters, with the exception of the second quarter.

- Concentrations of arsenic measured at ASKY-M span three orders of magnitude, ranging from 0.003 ng/m³ to 5.97 ng/m³ plus one non-detect, with a median concentration of 0.94 ng/m³. The maximum arsenic concentration was measured at ASKY-M on the same day as the second highest manganese concentration was measured at this site. Although the first and fourth quarter average concentrations are less than the other two quarterly averages, they have larger confidence intervals, indicating more variability in their measurements. While the two highest arsenic concentrations were measured during the fourth (5.97 ng/m³ on November 30, 2013) and first (4.40 ng/m³ on March 29, 2013) quarters of 2013 at ASKY-M, all eight arsenic concentrations less than 0.30 ng/m³ were also measured during the first or fourth quarters of 2013.
- Table 4-12 presents the NMP sites with the 10 highest annual average concentrations for each of the program-level metal pollutants of interest. This table shows that the highest annual averages for arsenic and nickel calculated across the program were calculated for ASKY-M.

Observations for GLKY from Table 14-6 include the following:

- GLKY sampled VOCs, carbonyl compounds, metals, PAHs, and hexavalent chromium. However, most of the pollutants of interest identified for GLKY are VOCs.
- The only pollutant of interest with an annual average concentration greater than 1 µg/m³ is formaldehyde (1.31 ± 0.20 µg/m³). However, this is one of the lowest annual averages of formaldehyde calculated among NMP sites sampling carbonyl compounds.
- Concentrations of formaldehyde were considerably higher during the warmer months of the year, based on the quarterly averages. The 18 highest measurements (those greater than 1.50 µg/m³) were measured during the second or third quarters of 2013. Conversely, all 27 concentrations less than 1.0 µg/m³ were measured in the first or fourth quarters.
- Concentrations of acetaldehyde do not exhibit the same tendency as formaldehyde. Concentrations of this pollutant were highest during the second quarter. The second quarter is the quarter during which the greatest number of concentrations greater than 1 µg/m³ were measured (six), with one each measured during the first and fourth quarters. A review of the median concentration for each quarter shows that the median concentrations follow a similar pattern as the quarterly averages, ranging from 0.55 µg/m³ to 0.61 µg/m³ for the first, third, and fourth quarters and 0.79 µg/m³ for the second quarter.

- Although the first quarter average concentration of benzene is the highest of the quarterly averages, the third quarter average has the highest associated confidence interval. A review of the data shows that the maximum benzene concentration was measured on August 8, 2013 ($2.75 \mu\text{g}/\text{m}^3$). A second benzene concentration of $1.29 \mu\text{g}/\text{m}^3$ was measured in September. All other benzene concentrations measured during the third quarter of 2013 are less than $0.5 \mu\text{g}/\text{m}^3$. Of the 16 benzene measurements greater than $0.5 \mu\text{g}/\text{m}^3$ measured at GLKY, 11 were measured during the first quarter, one was measured during the second quarter, and two each were measured in the third and fourth quarters.
- Arsenic is the only other pollutant of interest for GLKY that is not a VOC or carbonyl compound. Concentrations of arsenic measured at GLKY range from $0.005 \text{ ng}/\text{m}^3$ to $2.07 \text{ ng}/\text{m}^3$, plus a single non-detect. Both the minimum and maximum concentrations of arsenic were measured at GLKY during the first quarter of 2013, explaining the relatively large confidence interval associated with this quarterly average. Fifteen of the 16 lowest concentrations measured at GLKY, including the non-detect, were measured in during the first or fourth quarters of 2013.

Observations for BAKY from Table 14-6 include the following:

- Only speciated metals were sampled for at BAKY; only two pollutants of interest were identified for BAKY: arsenic and nickel.
- Nickel was measured in all 60 valid metals samples collected at BAKY, while a single non-detect of arsenic was measured.
- Concentrations of arsenic tended to be higher than the concentrations of nickel measured at this site, as evident from the annual averages and quarterly averages shown in Table 14-6 (although the fourth quarter averages of these metals are equal to each other). For both metals, concentrations appear higher during the warmer months of the year, although the differences are not statistically significant.
- Arsenic concentrations measured at BAKY range from $0.01 \text{ ng}/\text{m}^3$ to $6.37 \text{ ng}/\text{m}^3$, plus the one non-detect, with a median concentration of $0.66 \text{ ng}/\text{m}^3$. The maximum arsenic concentration was measured on September 7, 2013 and is more than three times greater than the next highest arsenic measurement collected at BAKY. The maximum and non-detect concentrations were both measured at BAKY during the third quarter of 2013. This explains the relatively high third quarter average concentration and associated confidence interval.
- Nickel concentrations measured at BAKY range from $0.11 \text{ ng}/\text{m}^3$ to $4.14 \text{ ng}/\text{m}^3$, with a median concentration of $0.46 \text{ ng}/\text{m}^3$. The maximum nickel concentration was measured on July 21, 2013 and is more than twice the next highest nickel measurement collected at BAKY ($1.96 \text{ ng}/\text{m}^3$ measured on May 28, 2013). At least one nickel concentration greater than $1 \text{ ng}/\text{m}^3$ was measured during each calendar quarter.

- As shown in Table 14-6, the first and fourth quarter nickel averages are similar to each other and have similar confidence intervals. The second and third quarter averages are similar to each other but their confidence intervals are considerably different. If median concentrations are calculated for each quarter's data, the median concentrations for the first and fourth quarters are both just less than 0.40 ng/m^3 , but the median for the second quarter (0.61 ng/m^3) is considerably higher than the median for the third quarter (0.49 ng/m^3). This indicates the nickel concentrations ran higher overall during the second quarter while the maximum concentration measured during the third quarter is influencing the quarterly average nickel concentration for the third quarter.
- Among NMP sites sampling PM_{10} metals, BAKY has the third highest annual average concentration of arsenic and the 10th highest annual average concentration of nickel, as shown in Table 4-12.

Observations for the Calvert City monitoring sites from Table 14-6 include the following:

- With the exception of CCKY, only VOC samples were collected at the Calvert City sites; PM_{10} metals were sampled for at CCKY in addition to VOCs.
- Some of the highest concentrations of VOCs were measured at the Calvert City sites and these data are reviewed in the bullets that follow.
- Vinyl chloride is an infrequently detected pollutant under the NMP in typical urban atmospheres. Across the program, this pollutant was detected in less than 15 percent of the total samples collected. Together, the five Calvert City sites account for more than 67 percent of the 243 measured detections of this pollutant. The Calvert City sites account for all 41 concentrations of vinyl chloride greater than $0.30 \text{ } \mu\text{g/m}^3$ measured across the program, including the 15 measurements greater than $1 \text{ } \mu\text{g/m}^3$. The maximum concentration of vinyl chloride across the program was measured at TVKY ($6.07 \text{ } \mu\text{g/m}^3$), although additional measurements greater than $4 \text{ } \mu\text{g/m}^3$ were measured at ATKY and BLKY.
- Vinyl chloride is a pollutant of interest for four of the five Calvert City sites (with CCKY as the exception). As shown in Table 14-6, annual average concentrations for these sites range from $0.07 \pm 0.04 \text{ } \mu\text{g/m}^3$ for LAKY to $0.60 \pm 0.31 \text{ } \mu\text{g/m}^3$ for TVKY. All of the annual average and quarterly average concentrations of vinyl chloride for these sites have relatively large confidence intervals, indicating the relatively large amount of variability associated with these measurements, including substitutions for non-detects.
- Another pollutant for which the highest concentrations program-wide were measured at the Calvert City sites is 1,2-dichloroethane. The 77 highest concentrations of 1,2-dichloroethane across the program were all measured at the Calvert City sites. This includes all 49 measurements greater than $1 \text{ } \mu\text{g/m}^3$, the eight greater than $10 \text{ } \mu\text{g/m}^3$ and the one greater than $100 \text{ } \mu\text{g/m}^3$ ($111 \text{ } \mu\text{g/m}^3$ measured at TVKY on November 18, 2013).

- 1,2-Dichloroethane is a pollutant of interest for all five Calvert City sites. Annual average concentrations for these sites range from $0.24 \pm 0.08 \mu\text{g}/\text{m}^3$ for CCKY to $3.75 \pm 3.68 \mu\text{g}/\text{m}^3$ for TVKY. With the exception of CCKY and perhaps ATKY, the annual average and quarterly average concentrations of 1,2-dichloroethane for these sites have relatively large confidence intervals, indicating the relatively large amount of variability associated with these measurements.
- Some of the highest measurements of carbon tetrachloride were also measured at the Calvert City sites, particularly TVKY. Of the 14 carbon tetrachloride concentrations greater than or equal to $1 \mu\text{g}/\text{m}^3$ measured across the program, 12 were measured at the Calvert City sites (eight at TVKY, one at LAKY, and three at BLKY). The maximum carbon tetrachloride concentration measured at BLKY on January 28, 2013 ($23.7 \mu\text{g}/\text{m}^3$) is an order of magnitude greater than the next highest carbon tetrachloride measurement across the program ($2.33 \mu\text{g}/\text{m}^3$ measured at TVKY on January 16, 2013) and the maximum carbon tetrachloride concentration measured at an NMP site since 2001.
- Carbon tetrachloride is a pollutant of interest for all five Calvert City sites. Annual average concentrations for ATKY, CCKY, and LAKY were similar to each other, ranging from $0.67 \pm 0.02 \mu\text{g}/\text{m}^3$ for ATKY and CCKY to $0.68 \pm 0.03 \mu\text{g}/\text{m}^3$ for LAKY while the annual averages were greater for TVKY ($0.80 \pm 0.08 \mu\text{g}/\text{m}^3$) and BLKY ($1.11 \pm 0.77 \mu\text{g}/\text{m}^3$). Quarterly averages for ATKY, CCKY, and LAKY span less than $0.1 \mu\text{g}/\text{m}^3$, ranging from $0.63 \mu\text{g}/\text{m}^3$ to $0.72 \mu\text{g}/\text{m}^3$, which are fairly typical for this pollutant among NMP sites. A review of the quarterly average concentrations for BLKY provides insight into when the higher concentrations of carbon tetrachloride were measured. The first quarter average concentration for BLKY ($2.21 \pm 3.16 \mu\text{g}/\text{m}^3$) is more than twice the other quarterly averages and the confidence interval is considerably greater than the average itself, indicating during which quarter the maximum concentration was measured. The third quarter average concentration for BLKY is also higher than the other quarterly averages and has a relatively large confidence interval ($0.82 \pm 0.13 \mu\text{g}/\text{m}^3$) for this pollutant. Although this average is nothing like the first quarter average, it is greater than quarterly averages typically calculated for this pollutant, which generally range from $0.55 \mu\text{g}/\text{m}^3$ to $0.75 \mu\text{g}/\text{m}^3$, with a central tendency around $0.65 \mu\text{g}/\text{m}^3$. Even the second quarter average concentration for BLKY is above this range. For TVKY, all of the quarterly average concentrations fall outside (and greater than) this range.
- All 19 1,3-butadiene concentrations greater than $1 \mu\text{g}/\text{m}^3$ measured across the program were measured at the Calvert City sites, including three greater than $20 \mu\text{g}/\text{m}^3$. Three of the four highest 1,3-butadiene concentrations across the program were measured on the same date at TVKY, LAKY, and CCKY (October 13, 2013) and ranged from $12.4 \mu\text{g}/\text{m}^3$ (CCKY) to $21.5 \mu\text{g}/\text{m}^3$ (TVKY) while the measurement at ATKY was considerably less ($0.05 \mu\text{g}/\text{m}^3$). No sample was collected at BLKY on this day. The COCs for this particular day indicate that on-going construction activities were occurring near TVKY, although this is noted on all samples collected between August and December.

- 1,3-Butadiene is a pollutant of interest for all five Calvert City sites. The annual average concentration of 1,3-butadiene for ATKY exhibits the least variability ($0.07 \pm 0.02 \mu\text{g}/\text{m}^3$) compared to the other Calvert City sites, which range from $0.26 \pm 0.40 \mu\text{g}/\text{m}^3$ for CCKY to $1.03 \pm 0.97 \mu\text{g}/\text{m}^3$ for TVKY. However, each of these five sites has at least one quarterly average concentration of 1,3-butadiene where the confidence interval is larger than the average itself. For ATKY, it's the second quarter average ($0.08 \pm 0.09 \mu\text{g}/\text{m}^3$), where 1,3-butadiene measurements range from $0.022 \mu\text{g}/\text{m}^3$ to $0.652 \mu\text{g}/\text{m}^3$ plus six non-detects. For other sites, the difference among the quarterly averages is larger and the calendar quarter during which an outlier was measured easily identified. For example, the quarterly average concentrations of 1,3-butadiene for CCKY range from $0.04 \pm 0.02 \mu\text{g}/\text{m}^3$ (first quarter) to $0.85 \pm 1.58 \mu\text{g}/\text{m}^3$ (fourth quarter). Each of the Calvert City sites has at least one quarterly average concentration like CCKY's fourth quarter average concentration, except ATKY.
- Hexachloro-1,3-butadiene is another infrequently detected pollutant that is a pollutant of interest for four of the five Calvert City sites (ATKY is the exception). The maximum hexachloro-1,3-butadiene concentration measured across the program was measured at BLKY ($0.29 \mu\text{g}/\text{m}^3$), along with the fourth and eighth highest concentrations of this pollutant. However, this pollutant was detected in no more than 20 percent of valid VOC sampled collected at each site; thus, zeros substituted for non-detects make up the majority of the measurements incorporated into the quarterly and annual averages shown in Table 14-6. As a result, the annual averages are not significantly different across the sites, ranging from $0.011 \pm 0.007 \mu\text{g}/\text{m}^3$ for ATKY to $0.019 \pm 0.010 \mu\text{g}/\text{m}^3$ for LAKY.
- 1,1,2-Trichloroethane is a pollutant of interest for two of the Calvert City sites, BLKY and TVKY. Together, these sites account for more than half (16) of the 29 measured detections of this pollutant across the program. Along with measurements from ATKY, CCKY, and LAKY, the Calvert City sites account for all but four of the 29 measured detections of 1,1,2-trichloroethane measured across the program. The program-level maximum concentration of this pollutant ($2.15 \mu\text{g}/\text{m}^3$) was measured at TVKY on November 18, 2013. No other concentration of 1,1,2-trichloroethane greater than $0.4 \mu\text{g}/\text{m}^3$ was measured at an NMP site in 2013.
- Benzene is the only other VOC that is a pollutant of interest across the Calvert City sites. Annual average concentrations of benzene range from $0.50 \pm 0.05 \mu\text{g}/\text{m}^3$ for CCKY to $1.06 \pm 0.32 \mu\text{g}/\text{m}^3$ for TVKY. Benzene concentrations measured at TVKY exhibit the most variability, ranging from $0.20 \mu\text{g}/\text{m}^3$ to $6.40 \mu\text{g}/\text{m}^3$. The maximum benzene concentration was measured on October 13, 2013, the same day that the highest 1,3-butadiene concentration was measured at this site. This is also the fourth highest benzene concentration measured across the program.
- Table 4-9 presents the NMP sites with the 10 highest annual average concentrations for each of the program-level VOC pollutants of interest. This table shows that TVKY has the ninth highest annual average benzene concentration among sites sampling this pollutant. Calvert City sites account for four of the five highest annual average concentrations of 1,3-butadiene across the program (with ATKY as the

exception). All five Calvert City sites rank among the sites with the highest annual average concentrations of carbon tetrachloride across the program, ranging from highest (BLKY) to seventh highest (ATKY). Calvert City sites account for the five highest annual average concentrations of 1,2-dichloroethane across the program. LAKY and BLKY rank eighth and ninth highest, respectively, among NMP sites for their annual average concentrations of hexachloro-1,3-butadiene.

- Arsenic is the only non-VOC pollutant of interest for CCKY. Concentrations of arsenic measured at CCKY range from 0.08 ng/m³ to 3.38 ng/m³, plus a single non-detect, with a median concentration of 0.49 ng/m³. The maximum concentration measured at CCKY is the ninth highest arsenic (PM₁₀) concentration measured across the program. This site has the ninth highest annual average concentration of arsenic among NMP sites sampling PM₁₀ metals, as shown in Table 4-12.

Observations for LEKY from Table 14-6 include the following:

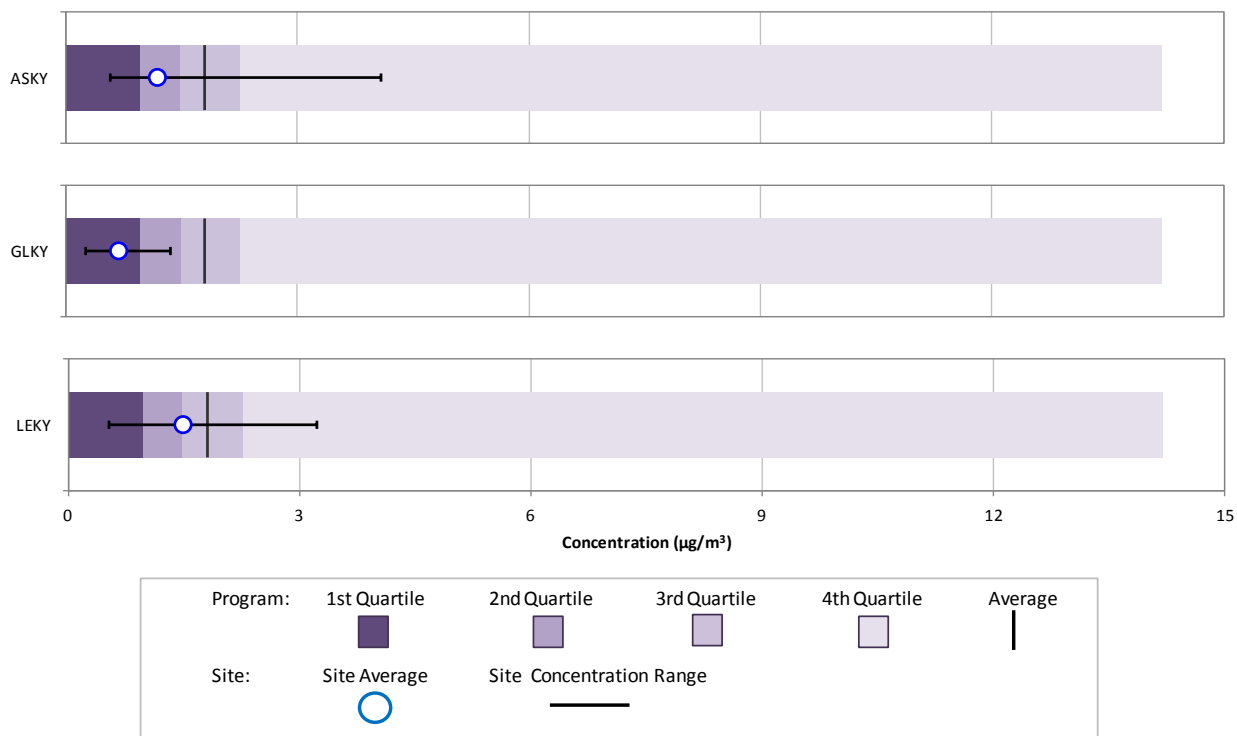
- Although VOCs were sampled for at LEKY year-round, a leak in the sample line was discovered at the site and resulted in the invalidation of VOC samples between February 9, 2013 and May 4, 2013; thus, first and second quarterly averages and annual averages for the VOC pollutants of interest could not be calculated. However, Appendix J provides the pollutant-specific average concentrations for all valid VOC samples collected at LEKY for the entire year.
- In most cases, the fourth quarter average concentrations were greater than the third quarter averages of the VOC pollutants of interest.
- The annual average concentration for formaldehyde is roughly twice the annual average concentration of acetaldehyde, the two carbonyl compound pollutants of interest for LEKY.
- The second and third quarter average concentrations of formaldehyde are significantly higher than the first and fourth quarter averages, indicating that formaldehyde concentrations tended to be higher during the warmer months of the year at this site. Concentrations of formaldehyde measured at LEKY range from 0.609 µg/m³ to 8.33 µg/m³, with the 17 highest measurements (those greater than 4 µg/m³) measured between May and September and the 19 lowest measurements (those less than 1.50 µg/m³) measured between January and March or October and December.
- Acetaldehyde concentrations appear lowest during the first quarter of 2013 and highest during the fourth quarter of 2013, although the differences between the second, third, and fourth quarterly averages are not statistically significant. Ten of the 12 lowest acetaldehyde concentrations (those less than 1 µg/m³) were measured between January and March. Three of the four highest acetaldehyde concentrations measured at LEKY were measured in October and November with nearly half (5) of the 11 acetaldehyde concentrations greater than 2 µg/m³ measured during the fourth quarter (and none measured during the first quarter and each three in the second and third quarters).

- Concentrations of arsenic measured at LEKY range from 0.08 ng/m³ to 2.53 ng/m³, including a single non-detect, with a median concentration of 0.67 ng/m³. Among NMP sites sampling PM₁₀ metals, LEKY has the seventh highest annual average concentration of arsenic, as shown in Table 4-12.
- It should be noted that during the second half of 2013, demolition of a nearby mental health hospital was completed.

14.4.2 Concentration Comparison

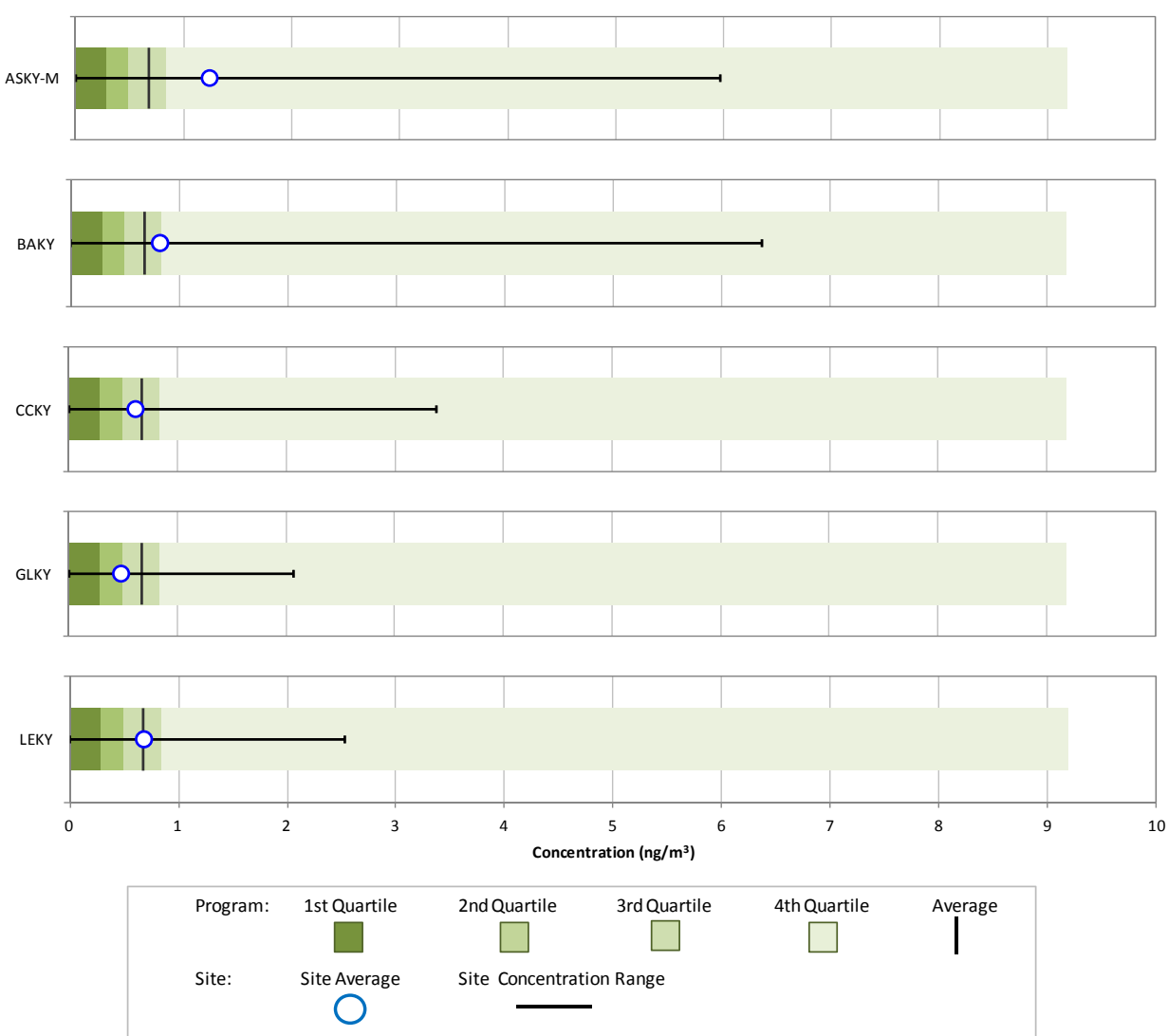
In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where annual averages are available. Thus, box plots were created for the pollutants of interest for each of the Kentucky monitoring sites. Figures 14-26 through 14-40 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1. Figures 14-26 through 14-40 and their associated observations are as follows:

Figure 14-26. Program vs. Site-Specific Average Acetaldehyde Concentrations



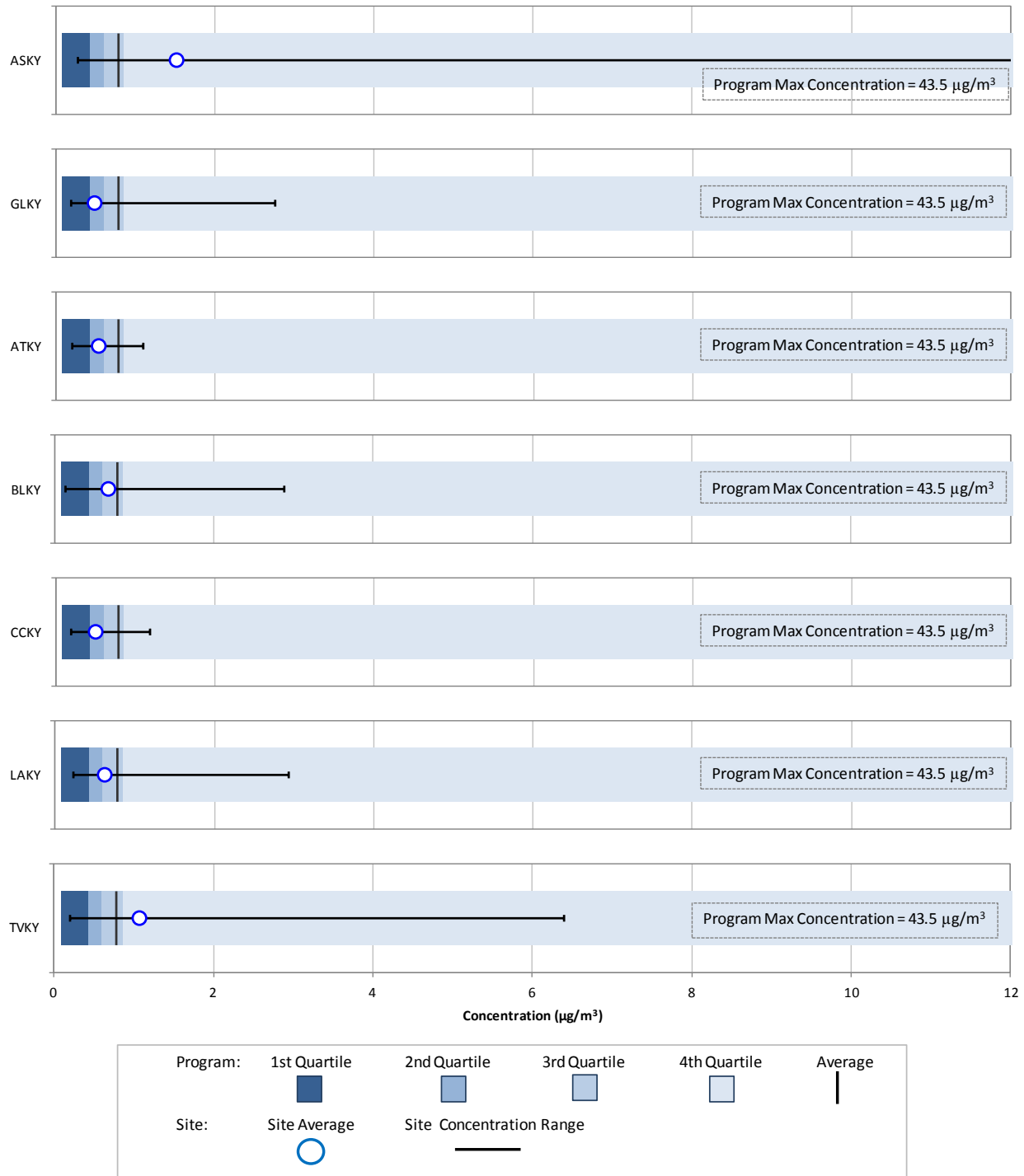
- Figure 14-26 is the box plot for acetaldehyde for ASKY, GLKY, and LEKY, the only Kentucky sites at which carbonyl compounds were sampled. The range of acetaldehyde concentrations measured was largest for ASKY and smallest for GLKY, with all of the acetaldehyde concentrations measured at GLKY less than the program-level median concentration. Among these three sites, GLKY has the lowest annual average concentration while LEKY has the highest, although each of the annual average concentrations is less than the program-level average concentration. LEKY's annual average concentration is similar to the program-level median concentration; ASKY's annual average is less than the program-level median but greater than the first quartile; and GLKY's annual average is less than the program-level first quartile.

Figure 14-27. Program vs. Site-Specific Average Arsenic (PM₁₀) Concentrations



- Figure 14-27 presents the box plots for the five Kentucky sites for which arsenic is a pollutant of interest. The box plots show that the range of arsenic concentrations measured is smallest for GLKY and largest for BAKY (although a similar range was measured at ASKY-M). The annual average concentrations of arsenic for ASKY-M and BAKY are greater than the program-level average concentration; the annual average concentration for LEKY is similar to the program-level average concentration; the annual average concentration for CCKY is just less than the program-level average concentration; and the annual average concentration for GLKY is less than the program-level average concentration but similar to the program-level median. The maximum arsenic concentration across the program was not measured at any of the Kentucky sites, even though these sites account for four of the highest annual average concentrations among NMP sites sampling PM₁₀ metals.

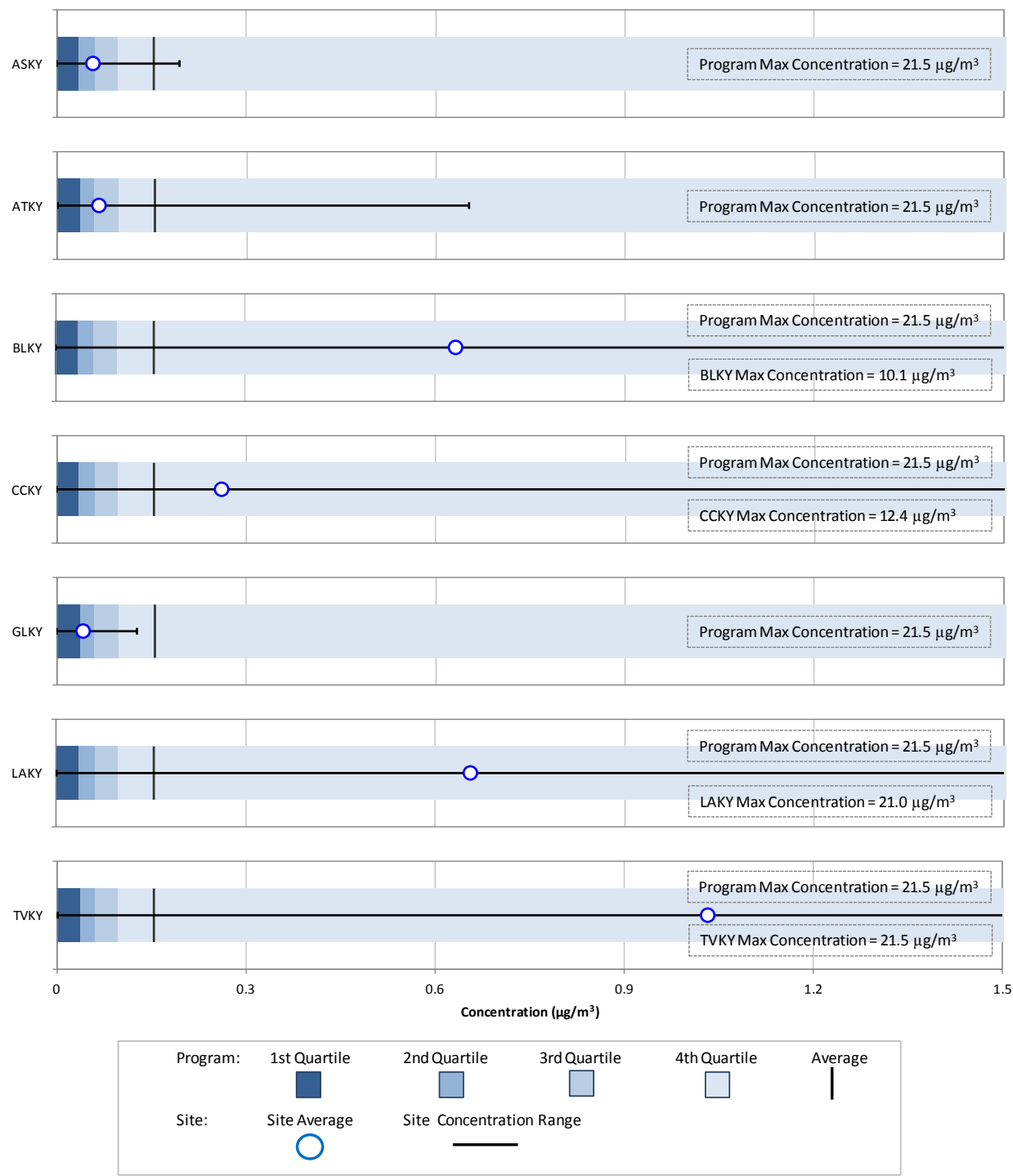
Figure 14-28. Program vs. Site-Specific Average Benzene Concentrations



- Figure 14-28 presents the box plots for the seven Kentucky sites for which benzene is a pollutant of interest. Note that the program-level maximum concentration (43.5 µg/m³) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plots has been reduced to 12 µg/m³. The box plots show that the maximum benzene concentration measured across the program was measured at ASKY. All other benzene concentrations

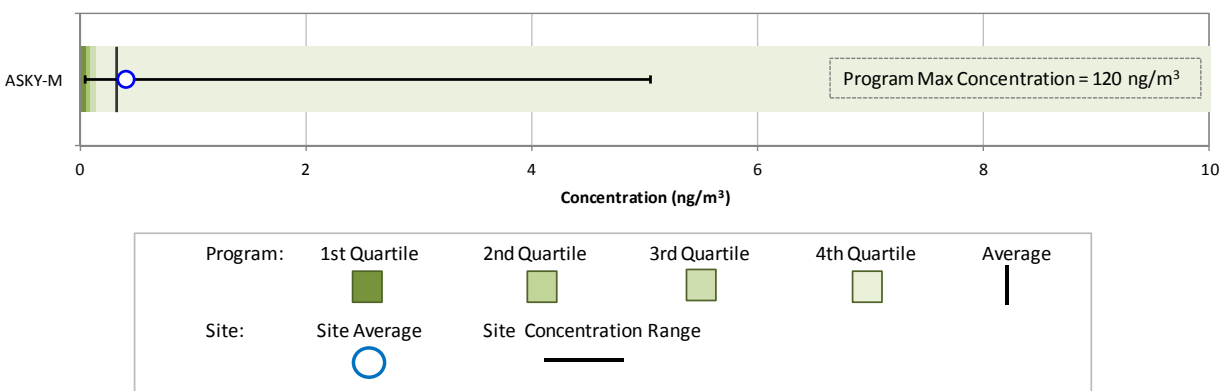
measured at a Kentucky site fall well within the range of benzene concentrations shown on the box plots. After ASKY, the range of benzene concentrations is largest at TVKY and smallest at ATKY (although a similar range was measured at CCKY). The annual average concentrations of benzene across all the Kentucky sites range from $0.49 \pm 0.10 \mu\text{g}/\text{m}^3$ (GLKY) to $1.52 \pm 1.39 \mu\text{g}/\text{m}^3$ (ASKY). The annual average benzene concentrations for ASKY and TVKY are the only ones greater than the program-level average concentration.

Figure 14-29. Program vs. Site-Specific Average 1,3-Butadiene Concentrations



- Figure 14-29 presents the box plots for the seven Kentucky sites for which 1,3-butadiene is a pollutant of interest. Note that the program-level maximum concentration ($21.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to $1.5 \mu\text{g}/\text{m}^3$. Also, since the maximum 1,3-butadiene concentration for several sites is greater than the scale of the box plots, the site-specific maximum concentrations are labeled for these sites. The maximum 1,3-butadiene concentration measured across the program was measured at TVKY, although maximum concentrations greater than the scale of the box plots were also measured at BLKY, CCKY, and LAKY. In each of these cases, the maximum concentrations were a full order of magnitude greater than the scale on the box plots. The annual average concentrations of 1,3-butadiene for TVKY, LAKY, and BLKY are at least twice the next highest annual average concentration (which was calculated for CCKY). With the exception of ATKY, each Calvert City site's annual average concentration is greater than the program-level concentration. Note that the program-level average concentration is considerably higher than the third quartile and more than twice the program-level median concentration, indicating that the 1,3-butadiene concentrations on the upper end of the concentration range are driving the program-level average upward. The annual average 1,3-butadiene concentrations for the two sites not located in Calvert City are less than or similar to the program-level median concentration.

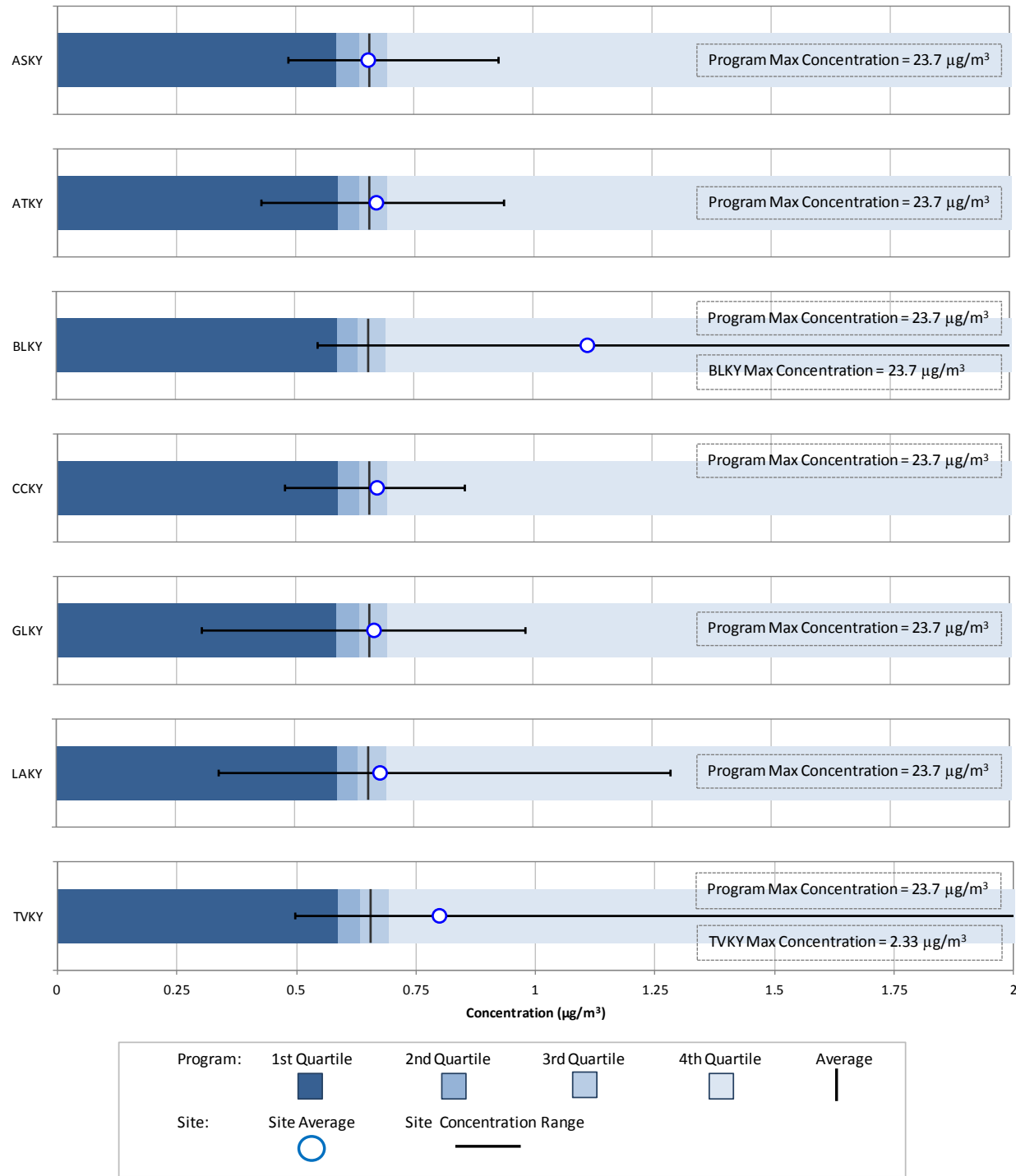
Figure 14-30. Program vs. Site-Specific Average Cadmium Concentration



- Figure 14-30 is the box plot for cadmium for ASKY-M, the only Kentucky site for which this is a pollutant of interest. Similar to other pollutants, the program-level maximum concentration ($120 \text{ ng}/\text{m}^3$) is not shown directly on the box plot for cadmium as the scale of the box plot has been reduced to $10 \text{ ng}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. Although the maximum concentration across the program was not measured at ASKY-M, the second highest cadmium concentration was measured at this site (although considerably less). The annual average concentration of cadmium for ASKY-M is just greater than the program-level average concentration. This site has the third highest annual average concentration of cadmium, behind only SEWA and S4MO. Note that the program-level average

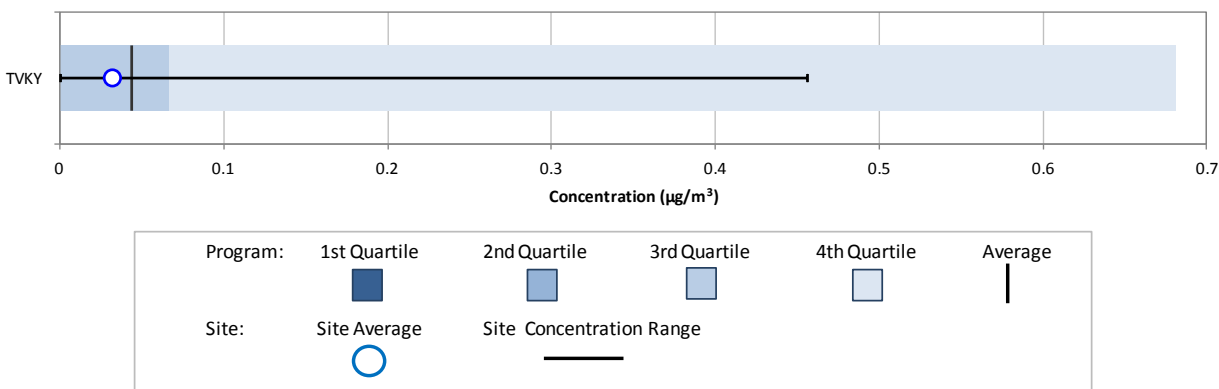
cadmium concentration is more than twice the third quartile and nearly four times the program-level median concentration, indicating that the cadmium concentrations on the upper end of the concentration range, particularly the maximum concentration, are driving the program-level average concentration upward.

Figure 14-31. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations



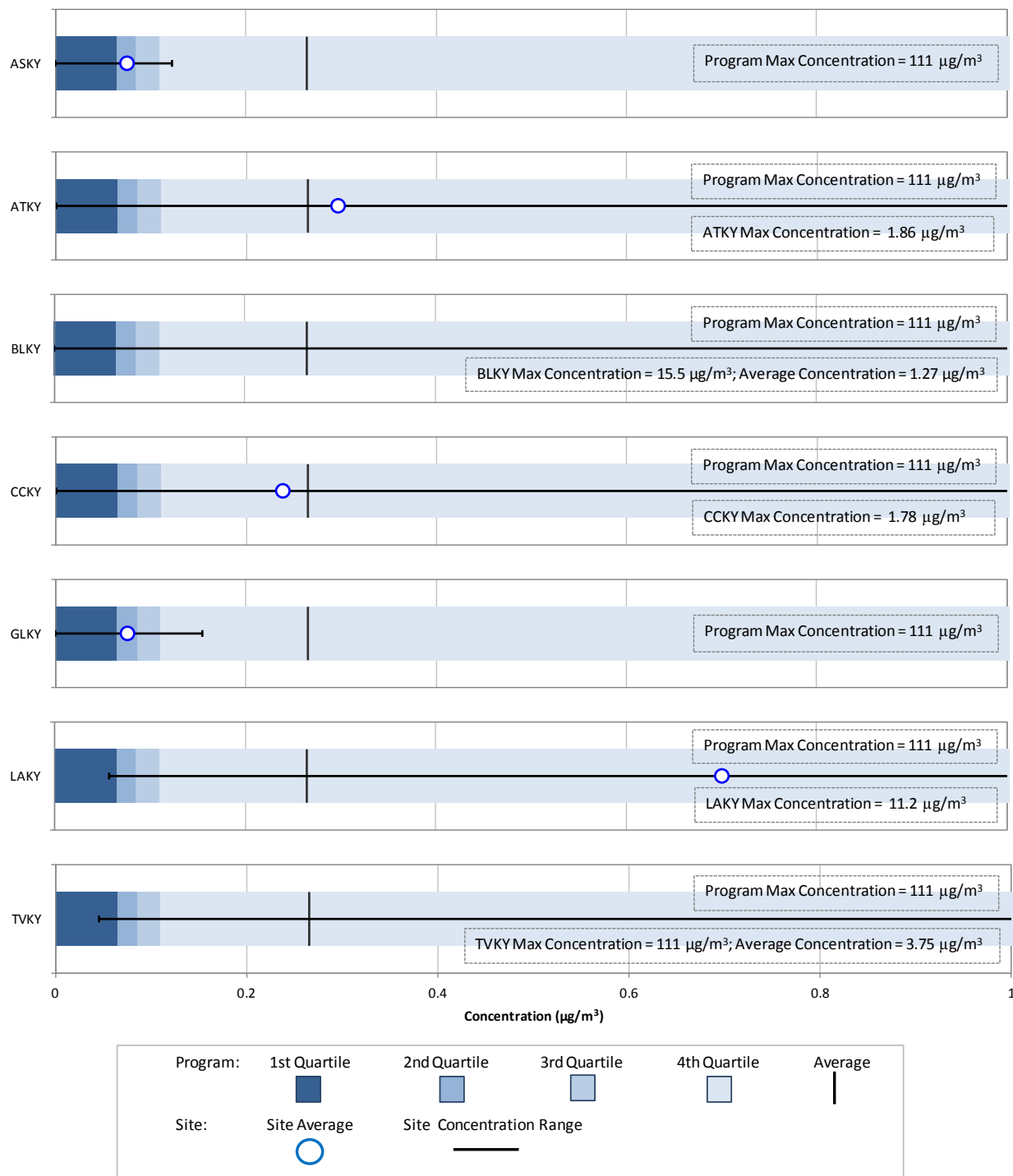
- Figure 14-31 presents the box plots for the seven Kentucky sites for which carbon tetrachloride is a pollutant of interest. Similar to other pollutants, the program-level maximum concentration ($23.7 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots for carbon tetrachloride as the scale of the box plots has been reduced to $2 \mu\text{g}/\text{m}^3$ in order to allow for the observations data points at the lower end of the concentration range. Also, since the maximum carbon tetrachloride concentration for several sites is greater than the scale of the box plots, the site-specific maximum concentrations are labeled for these sites. The maximum carbon tetrachloride concentration measured across the program was measured at BLKY. Although the maximum carbon tetrachloride concentration measured at TVKY is also greater than the scale of the box plot, the measurement was an order of magnitude less ($2.33 \mu\text{g}/\text{m}^3$). The annual average concentrations for TVKY and BLKY are higher than the annual averages for the other sites as well as the program-level average, which all fall between the program-level median and third quartile.

Figure 14-32. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentration



- Figure 14-32 is the box plot for *p*-dichlorobenzene for TVKY, the only Kentucky site for which this is a pollutant of interest. Note that the first and second quartiles are both zero for this pollutant, indicating that at least half of the measurements are non-detects and thus, are not visible on the box plot. The maximum concentration measured at TVKY is less than the maximum concentration measured across the program but still among the higher measurements. The annual average *p*-dichlorobenzene concentration for TVKY is less than the program-level average concentration and is the lowest annual average concentration among NMP sites for which this is a pollutant of interest.

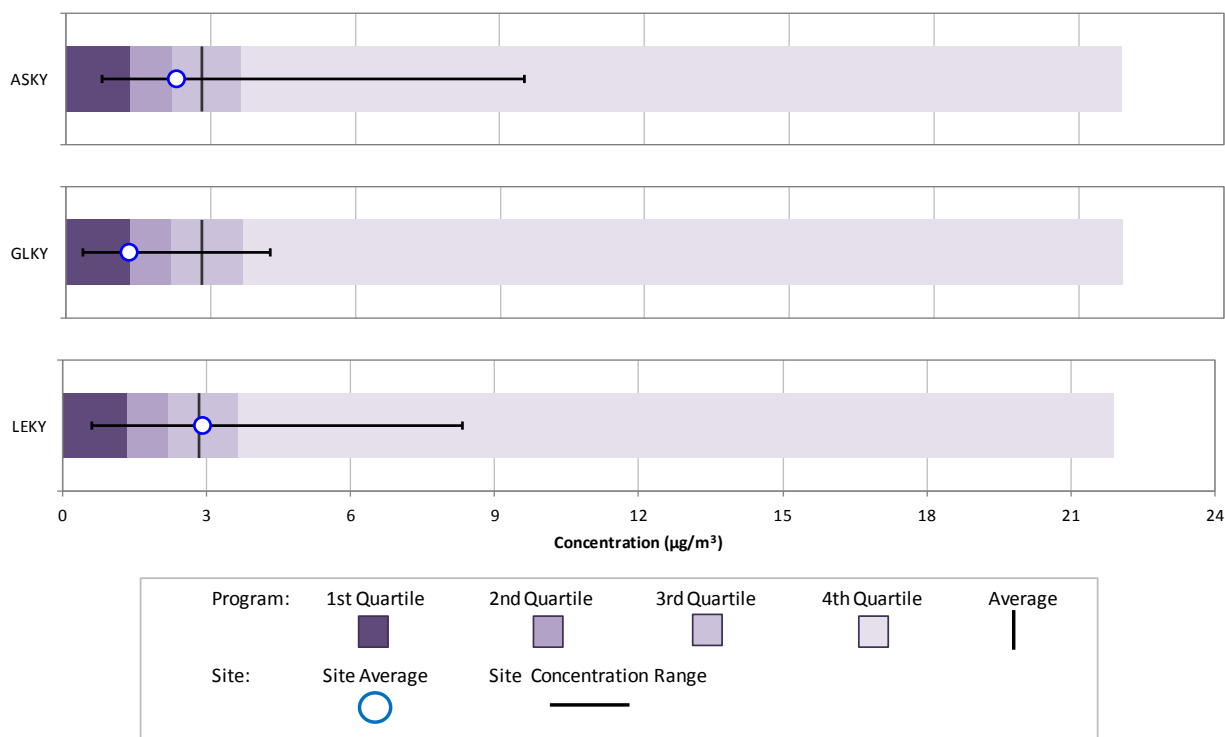
Figure 14-33. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations



- Figure 14-33 presents the box plots for the seven Kentucky sites for which 1,2-dichloroethane is a pollutant of interest. Similar to other pollutants, the program-level maximum concentration ($111 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots for 1,2-dichloroethane as the scale of the box plots has been reduced to $1 \mu\text{g}/\text{m}^3$ in order to allow for the observations data points at the lower end of the concentration range. Also, since the maximum 1,2-dichloroethane concentration for several sites is greater than the scale of the box plots, the site-specific

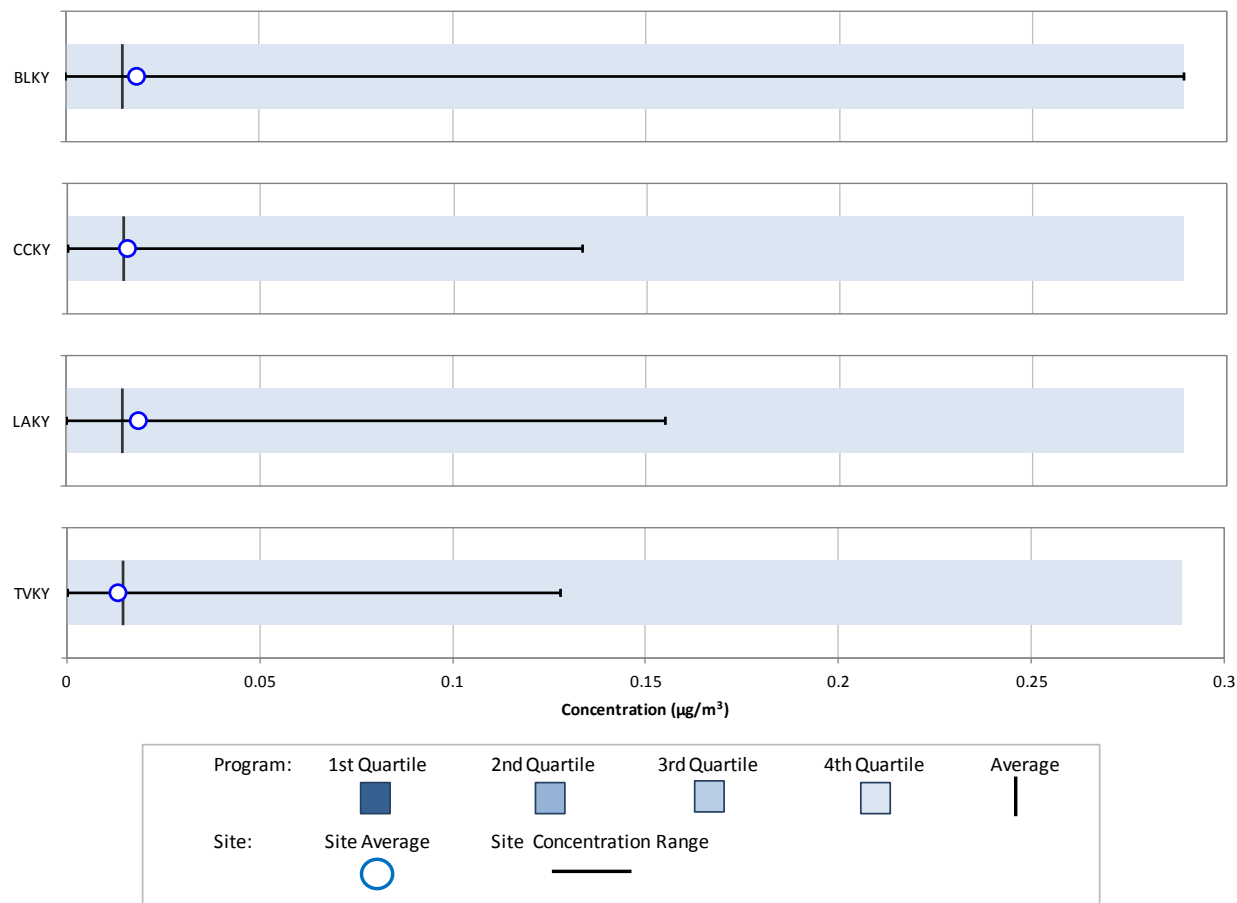
maximum concentrations are labeled for these sites. The range of 1,2-dichloroethane concentrations measured at each Calvert City site exceeds the scale of the box plots; by comparison, the entire range of 1,2-dichloroethane concentrations measured at ASKY and GLKY is less than the first gridline on the box plots ($0.2 \mu\text{g}/\text{m}^3$). In addition, the annual average 1,2-dichloroethane concentrations for BLKY and TVKY exceed the scale of the box plots and are also labeled on the box plots for these sites. Note that the program-level average 1,2-dichloroethane concentration is considerably higher than the program-level median and third quartile, indicating that the concentrations on the upper end of the concentration range are driving the program-level average upward. Recall from the previous section that the annual average concentrations for the Calvert City sites account for the five highest 1,2-dichloroethane concentrations among NMP sites sampling VOCs. The only Calvert City site with an annual average concentration less than the program-level average is CCKY, although it is still more than twice the annual average for the NMP monitoring site with the next highest annual average (BTUT), as shown in Table 4-9.

Figure 14-34. Program vs. Site-Specific Average Formaldehyde Concentrations



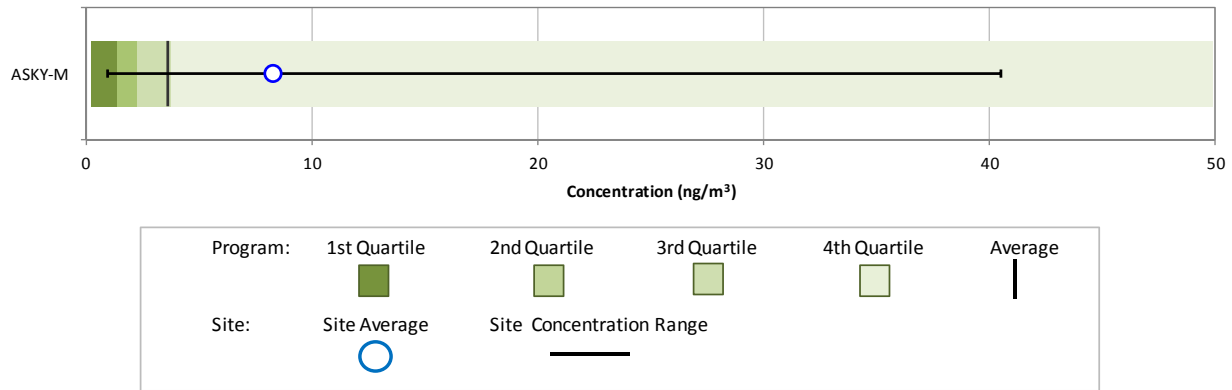
- Figure 14-34 is the box plot for formaldehyde for ASKY, GLKY, and LEKY, the only Kentucky sites at which carbonyl compounds were sampled. The range of formaldehyde concentrations measured was largest for ASKY and smallest for GLKY. Among these three sites, GLKY has the lowest annual average concentration while LEKY has the highest. LEKY's annual average is similar to the program-level average concentration; ASKY's annual average falls between the program-level median and average concentrations; and GLKY's is similar to the program-level first quartile.

Figure 14-35. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentrations



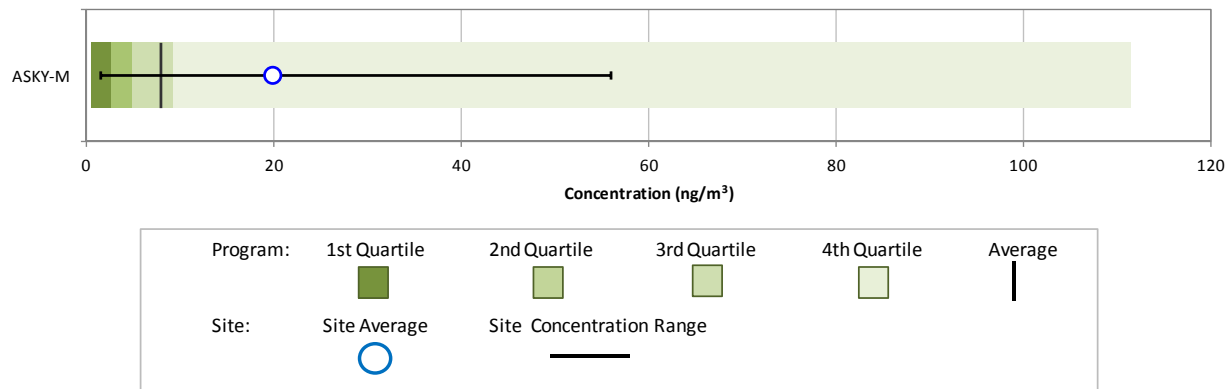
- Figure 14-35 is the box plot for hexachloro-1,3-butadiene for BLKY, CCKY, LAKY, and TVKY, the Kentucky sites for which this is a pollutant of interest. Note that the first, second, and third quartiles are all zero for this pollutant, indicating that at least 75 percent of the measurements are non-detects and thus, are not visible on the box plots. The maximum hexachloro-1,3-butadiene concentration measured at BLKY is the maximum hexachloro-1,3-butadiene concentration measured across the program. Even though the annual average hexachloro-1,3-butadiene concentrations for all of the sites shown are similar to the program-level average concentration, the annual averages of this pollutant for all NMP sites sampling VOCs fall within a relatively tight range across the program (spanning less than $0.03 \mu\text{g}/\text{m}^3$ for all NMP sites sampling VOCs).

Figure 14-36. Program vs. Site-Specific Average Lead (PM₁₀) Concentration



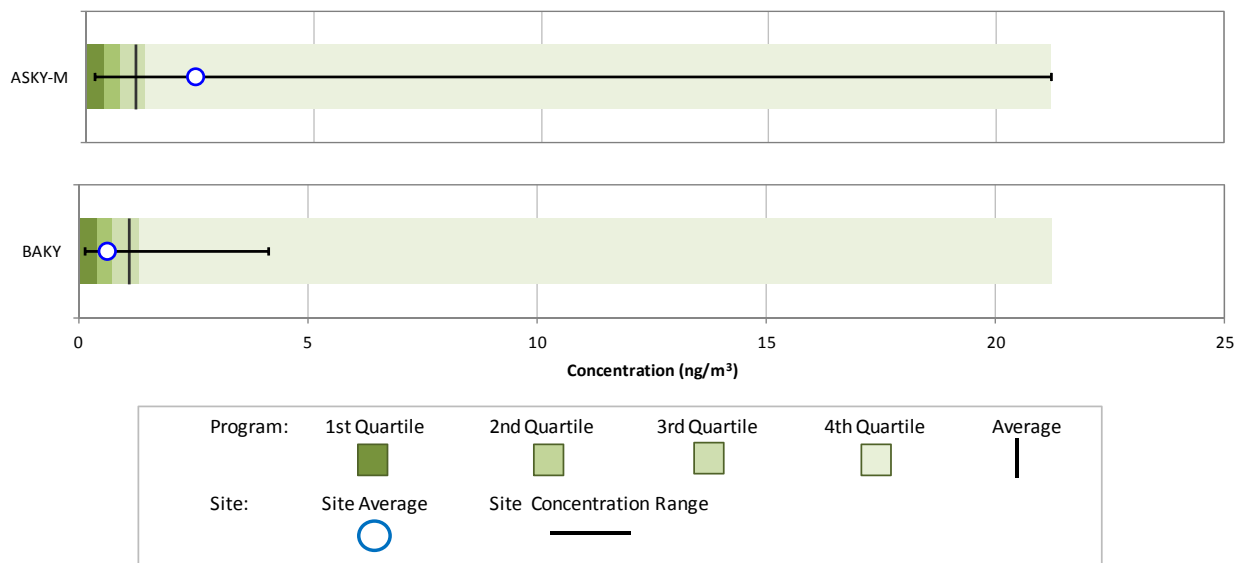
- Figure 14-36 is the box plot for lead for ASKY-M, the only Kentucky site for which lead was identified as a pollutant of interest. Although the maximum lead concentration across the program was not measured at ASKY-M, this site does have one of the higher measurements. The annual average concentration of lead for ASKY-M is more than two times greater than the program-level average concentration and is the second highest annual average concentration of lead calculated among NMP sites sampling PM₁₀ metals (behind S4MO). Note that ASKY-M is one of only two NMP sites sampling metals for which lead is a pollutant of interest (S4MO is the other).

Figure 14-37. Program vs. Site-Specific Average Manganese (PM₁₀) Concentration



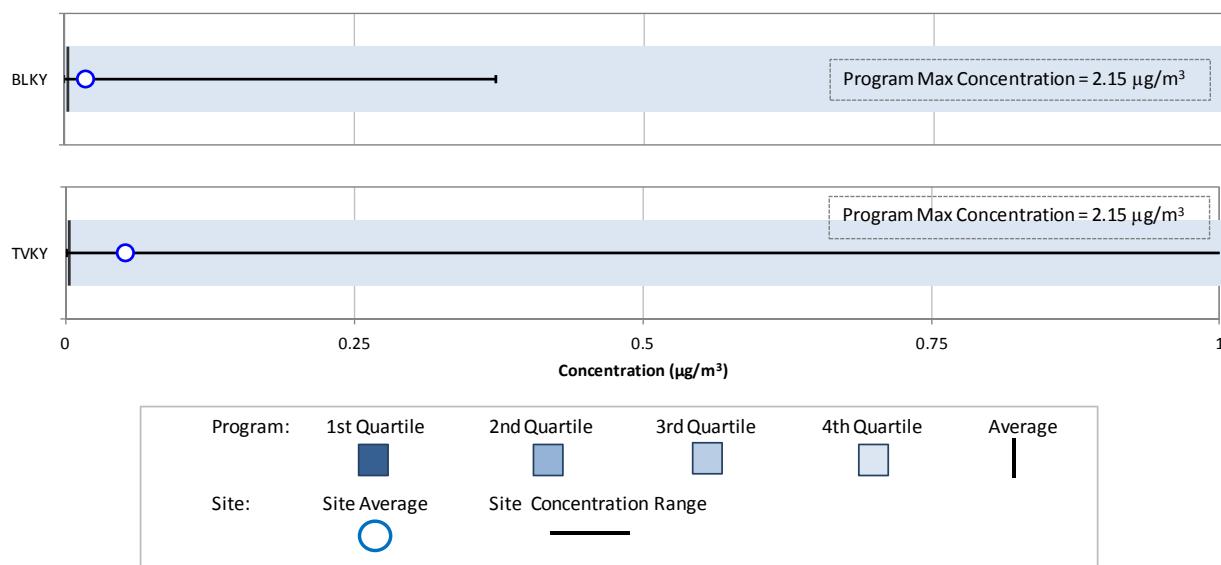
- Figure 14-37 is the box plot for manganese (PM₁₀) for ASKY-M, the only Kentucky site for which manganese was identified as a pollutant of interest. Although the maximum manganese concentration across the program was not measured at ASKY-M, this site does have one of the higher measurements, including the fourth through 13th highest concentrations. The annual average concentration of manganese for ASKY-M is nearly five times greater than the program-level average concentration and is the highest annual average concentration of manganese calculated among NMP sites sampling PM₁₀ metals. Note that ASKY-M is the only NMP site sampling PM₁₀ metals for which manganese is a pollutant of interest.

Figure 14-38. Program vs. Site-Specific Average Nickel (PM₁₀) Concentrations



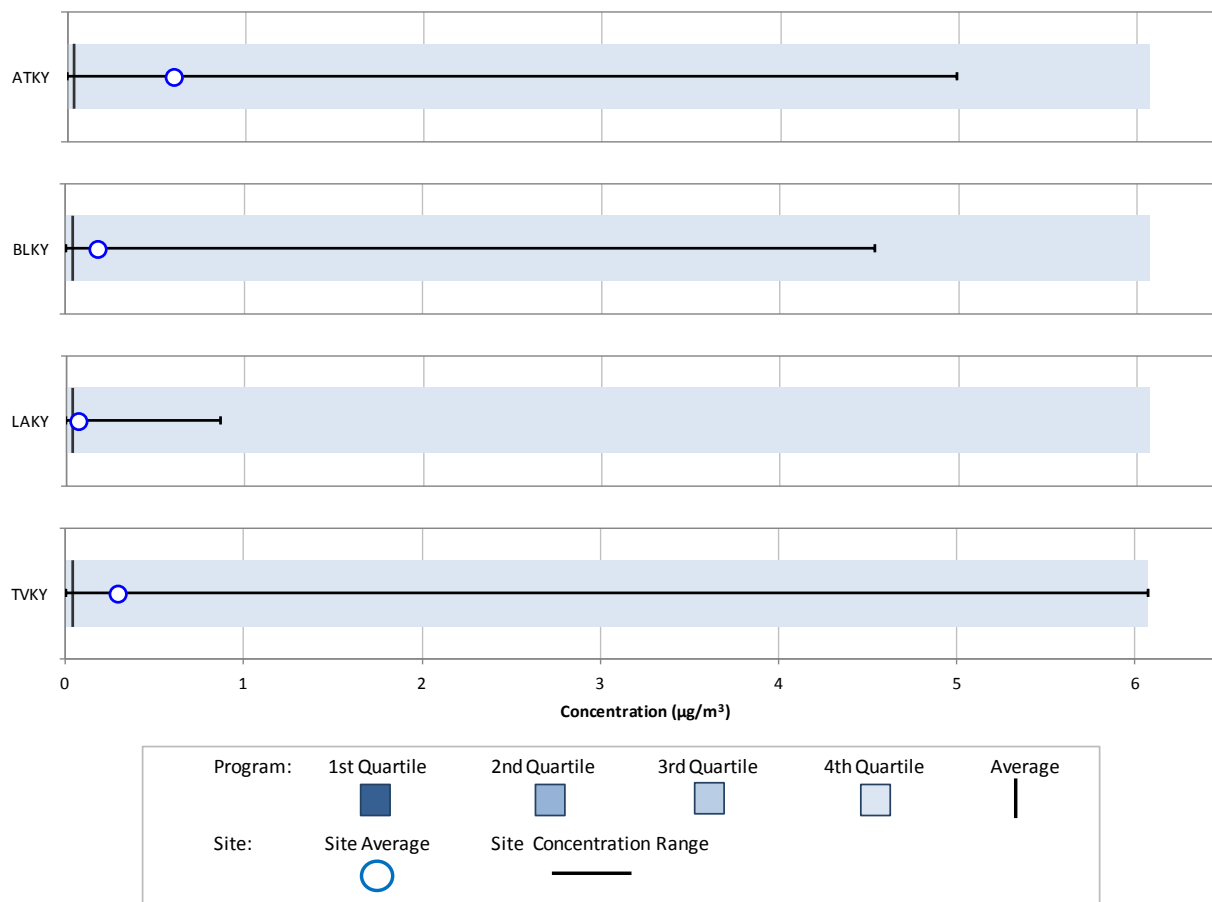
- Figure 14-38 presents the box plots for nickel for ASKY-M and BAKY. The box plots show that the maximum nickel concentration measured across the program was measured at ASKY-M. The maximum nickel concentration measured at BAKY is considerably less. The annual average concentration of nickel for ASKY-M is more than two times greater than the program-level average concentration and is the highest annual average concentration of nickel calculated among NMP sites sampling PM₁₀ metals. By comparison, the annual average concentration of nickel for BAKY is roughly one-fourth as high and ranks 10th across the program.

Figure 14-39. Program vs. Site-Specific Average 1,1,2-Trichloroethane Concentrations



- Figure 14-39 presents the box plots for 1,1,2-trichloroethane for BLKY and TVKY, the only Kentucky sites for which this is a pollutant of interest. The program-level maximum concentration ($2.15 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots for 1,1,2-trichloroethane as the scale of the box plots has been reduced to $1 \mu\text{g}/\text{m}^3$ in order to allow for the observations data points at the lower end of the concentration range. Also, the first, second, and third quartiles are all zero for this pollutant, indicating that at least 75 percent of the measurements are non-detects and thus, are not visible on the box plots. The maximum 1,1,2-trichloroethane concentration measured at TVKY is the maximum 1,1,2-trichloroethane concentration measured across the program. The annual average 1,1,2-trichloroethane concentrations for these two sites are an order of magnitude greater than the program-level average concentration. As discussed previously most of the measured detections of this pollutant were measured at the Calvert City sites, TVKY and BLKY in particular, and these are the only two NMP sites across the program with 1,1,2-trichloroethane as a pollutant of interest.

Figure 14-40. Program vs. Site-Specific Average Vinyl Chloride Concentrations



- Figure 14-40 presents the box plots for vinyl chloride for ATKY, BLKY, LAKY, and TVKY, the only Kentucky sites for which this is a pollutant of interest. The first, second, and third quartiles are all zero for this pollutant, indicating that at least 75 percent of the measurements are non-detects and thus, are not visible on

the box plots. The maximum vinyl chloride concentration measured at TVKY is the maximum concentration measured across the program, although several concentrations greater than $4 \mu\text{g}/\text{m}^3$ were also measured at ATKY and BLKY. The annual average vinyl chloride concentrations for these sites range from $0.07 \pm 0.04 \mu\text{g}/\text{m}^3$ for LAKY to $0.60 \pm 0.31 \mu\text{g}/\text{m}^3$ for ATKY, all of which are greater than the program-level average concentration of $0.04 \mu\text{g}/\text{m}^3$. The number of measured detections ranges from 29 for LAKY to 38 for ATKY for the sites shown, with 26 measured at the fifth Calvert City site (CCKY). The other NMP sites combined measured no more than 14 measured detections of this pollutant, with most measuring three or less.

14.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. The only pollutant group for which GLKY has sampled under the NMP since at least 2009 is hexavalent chromium and PAHs (sampling of VOCs at GLKY began in 2010, and carbonyl compounds and PM_{10} metals in 2011); however, hexavalent chromium did not fail any screens and none of the PAHs that failed screens were identified as pollutants of interest for GLKY. Thus, a trends analysis was not performed for this site. The remaining Kentucky sites did not begin sampling under the NMP until 2012.

14.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the Kentucky monitoring sites. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

14.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Kentucky monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard

approximations are presented in Table 14-7, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 14-7. Risk Approximations for the Kentucky Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Health Department, Ashland, Kentucky - ASKY						
Acetaldehyde	0.0000022	0.009	61/61	1.19 ± 0.14	2.62	0.13
Benzene	0.0000078	0.03	61/61	1.52 ± 1.39	11.85	0.05
1,3-Butadiene	0.00003	0.002	47/61	0.06 ± 0.01	1.71	0.03
Carbon Tetrachloride	0.000006	0.1	61/61	0.65 ± 0.02	3.92	0.01
1,2-Dichloroethane	0.000026	2.4	53/61	0.08 ± 0.01	1.95	<0.01
Formaldehyde	0.000013	0.0098	61/61	2.30 ± 0.38	29.87	0.23
21st and Greenup, Ashland, Kentucky - ASKY-M						
Arsenic (PM ₁₀) ^a	0.0043	0.000015	59/60	1.24 ± 0.29	5.34	0.08
Cadmium (PM ₁₀) ^a	0.0018	0.00001	60/60	0.40 ± 0.19	0.72	0.04
Lead (PM ₁₀) ^a	--	0.00015	60/60	8.25 ± 1.89	--	0.06
Manganese (PM ₁₀) ^a	--	0.0003	60/60	19.86 ± 4.06	--	0.07
Nickel (PM ₁₀) ^a	0.00048	0.00009	60/60	2.40 ± 0.89	1.15	0.03
Grayson, Kentucky - GLKY						
Acetaldehyde	0.0000022	0.009	61/61	0.68 ± 0.06	1.50	0.08
Benzene	0.0000078	0.03	61/61	0.49 ± 0.10	3.79	0.02
1,3-Butadiene	0.00003	0.002	48/61	0.04 ± 0.01	1.24	0.02
Carbon Tetrachloride	0.000006	0.1	61/61	0.67 ± 0.03	3.99	0.01
1,2-Dichloroethane	0.000026	2.4	56/61	0.08 ± 0.01	1.96	<0.01
Formaldehyde	0.000013	0.0098	61/61	1.31 ± 0.20	17.05	0.13
Arsenic (PM ₁₀) ^a	0.0043	0.000015	58/59	0.48 ± 0.10	2.08	0.03

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.
NA = Not available due to the criteria for calculating an annual average.

-- = A Cancer URE or Noncancer RfC is not available.

Table 14-7. Risk Approximations for the Kentucky Monitoring Sites (Continued)

Pollutant	Cancer URE (µg/m ³) ⁻¹	Noncancer RfC (mg/m ³)	# of Measured Detections vs. # of Samples	Annual Average (µg/m ³)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Baskett, Kentucky - BAKY						
Arsenic (PM ₁₀) ^a	0.0043	0.000015	59/60	0.82 ± 0.22	3.53	0.05
Nickel (PM ₁₀) ^a	0.00048	0.00009	60/60	0.61 ± 0.15	0.29	0.01
Atmos Energy, Calvert City, Kentucky - ATKY						
Benzene	0.0000078	0.03	61/61	0.54 ± 0.05	4.18	0.02
1,3-Butadiene	0.00003	0.002	44/61	0.07 ± 0.02	1.98	0.03
Carbon Tetrachloride	0.000006	0.1	61/61	0.67 ± 0.02	4.02	0.01
1,2-Dichloroethane	0.000026	2.4	60/61	0.30 ± 0.10	7.71	<0.01
Vinyl chloride	0.0000088	0.1	38/61	0.60 ± 0.31	5.24	0.01
Smithland, Kentucky - BLKY						
Benzene	0.0000078	0.03	59/59	0.67 ± 0.15	5.26	0.02
1,3-Butadiene	0.00003	0.002	39/59	0.63 ± 0.49	18.98	0.32
Carbon Tetrachloride	0.000006	0.1	59/59	1.11 ± 0.77	6.69	0.01
1,2-Dichloroethane	0.000026	2.4	57/59	1.27 ± 0.75	33.15	<0.01
Hexachloro-1,3-butadiene	0.000022	0.09	8/59	0.02 ± 0.01	0.40	<0.01
1,1,2-Trichloroethane	0.000016	0.4	7/59	0.02 ± 0.02	0.29	<0.01
Vinyl chloride	0.0000088	0.1	35/59	0.18 ± 0.16	1.56	<0.01
Calvert City Elementary School, Calvert City, Kentucky - CCKY						
Benzene	0.0000078	0.03	61/61	0.50 ± 0.05	3.87	0.02
1,3-Butadiene	0.00003	0.002	45/61	0.26 ± 0.40	7.80	0.13
Carbon Tetrachloride	0.000006	0.1	61/61	0.67 ± 0.02	4.03	0.01
1,2-Dichloroethane	0.000026	2.4	59/61	0.24 ± 0.08	6.20	<0.01
Hexachloro-1,3-butadiene	0.000022	0.09	11/61	0.02 ± 0.01	0.34	<0.01
Arsenic (PM ₁₀) ^a	0.0043	0.000015	55/56	0.61 ± 0.15	2.64	0.04

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m³ for ease of viewing.

NA = Not available due to the criteria for calculating an annual average.

-- = A Cancer URE or Noncancer RfC is not available.

Table 14-7. Risk Approximations for the Kentucky Monitoring Sites (Continued)

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$)⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Lazy Daze, Calvert City, Kentucky - LAKY						
Benzene	0.0000078	0.03	60/60	0.62 ± 0.11	4.86	0.02
1,3-Butadiene	0.00003	0.002	48/60	0.66 ± 0.80	19.67	0.33
Carbon Tetrachloride	0.000006	0.1	60/60	0.68 ± 0.03	4.07	0.01
1,2-Dichloroethane	0.000026	2.4	60/60	0.70 ± 0.45	18.21	<0.01
Hexachloro-1,3-butadiene	0.000022	0.09	12/60	0.02 ± 0.01	0.41	<0.01
Vinyl chloride	0.0000088	0.1	29/60	0.07 ± 0.04	0.59	<0.01
TVA Substation, Calvert City, Kentucky - TVKY						
Benzene	0.0000078	0.03	61/61	1.06 ± 0.32	8.29	0.04
1,3-Butadiene	0.00003	0.002	46/61	1.03 ± 0.97	30.97	0.52
Carbon Tetrachloride	0.000006	0.1	61/61	0.80 ± 0.08	4.80	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	24/61	0.03 ± 0.02	0.35	<0.01
1,2-Dichloroethane	0.000026	2.4	61/61	3.75 ± 3.68	97.42	<0.01
Hexachloro-1,3-butadiene	0.000022	0.09	11/61	0.01 ± 0.01	0.29	<0.01
1,1,2-Trichloroethane	0.000016	0.4	9/61	0.05 ± 0.07	0.82	<0.01
Vinyl chloride	0.0000088	0.1	36/61	0.29 ± 0.22	2.57	<0.01
Lexington, Kentucky - LEKY						
Acetaldehyde	0.0000022	0.009	61/61	1.49 ± 0.15	3.27	0.17
Benzene	0.0000078	0.03	45/45	NA	NA	NA
1,3-Butadiene	0.00003	0.002	41/45	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	45/45	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	43/45	NA	NA	NA
Formaldehyde	0.000013	0.0098	61/61	2.91 ± 0.49	37.85	0.30
Hexachloro-1,3-butadiene	0.000022	0.09	9/45	NA	NA	NA
Arsenic (PM ₁₀) ^a	0.0043	0.000015	52/53	0.68 ± 0.12	2.93	0.05

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m³ for ease of viewing.

NA = Not available due to the criteria for calculating an annual average.

-- = A Cancer URE or Noncancer RfC is not available.

Observations for the Kentucky monitoring sites from Table 14-7 include the following:

- The pollutants with the highest annual average concentrations for ASKY are formaldehyde, benzene, and acetaldehyde. Formaldehyde and benzene are the only two pollutants with cancer risk approximations greater than 10 in-a-million for ASKY (29.87 in-a-million and 11.85 in-a-million, respectively). All of the noncancer hazard approximations for the pollutants of interest for ASKY are considerably less than an HQ of 1.0 (0.23 or less), indicating that no adverse noncancer health effects are expected from these individual pollutants.
- The pollutants with the highest annual average concentrations for ASKY-M are manganese, lead, and nickel. Arsenic has the highest cancer risk approximation among ASKY-M's pollutants of interest (5.34 in-a-million). All of the noncancer hazard approximations for the pollutants of interest for ASKY-M are considerably less than an HQ of 1.0 (0.08 or less), indicating that no adverse noncancer health effects are expected from these individual pollutants.
- Formaldehyde is the only pollutant of interest for GLKY with an annual average concentration greater than 1 $\mu\text{g}/\text{m}^3$. This pollutant also has the only cancer risk approximation greater than 10 in-a-million for GLKY (17.05 in-a-million). All of the noncancer hazard approximations for the pollutants of interest for GLKY are considerably less than an HQ of 1.0 (0.13 or less), indicating that no adverse noncancer health effects are expected from these individual pollutants.
- Arsenic and nickel are the only pollutants of interest for BAKY. Arsenic has a cancer risk approximation greater than 1 in-a-million for BAKY (3.53 in-a-million) while nickel does not. The noncancer hazard approximations for the two pollutants of interest for BAKY are considerably less than an HQ of 1.0 (0.05 or less), indicating that no adverse noncancer health effects are expected from these individual pollutants.
- With the exception of ATKY, 1,3-butadiene and 1,2-dichloroethane have the highest cancer risk approximations among the pollutants of interest for the Calvert City sites. Cancer risk approximations for 1,3-butadiene range from 1.98 in-a-million for ATKY to 30.97 in-a-million for TVKY, with the cancer risk approximations for TVKY, LAKY, BLKY, and CCKY ranking highest among all sites sampling this pollutant. Cancer risk approximations for 1,2-dichloroethane range from 6.20 in-a-million for CCKY to 97.42 in-a-million for TVKY, with the cancer risk approximations for TVKY, BLKY, LAKY, ATKY, and CCKY ranking highest among all sites sampling this pollutant. Further, the cancer risk approximation for TVKY is the second highest among all cancer risk approximations calculated for the site-specific pollutants of interest (behind only BTUT's formaldehyde cancer risk approximation).
- Benzene and carbon tetrachloride have the next highest cancer risk approximations among the pollutants of interest for the Calvert City sites. Cancer risk approximations for benzene range from 3.87 in-a-million for CCKY to 8.29 in-a-million for TVKY. Cancer risk approximations for carbon tetrachloride range from 4.02 in-a-million for ATKY to 6.69 in-a-million for BLKY. The cancer risk approximations for BLKY and TVKY rank highest among all sites sampling this carbon tetrachloride.

- Vinyl chloride is another pollutant of interest that most of the Calvert City sites have in common (CCKY is the exception). Cancer risk approximations for vinyl chloride range from 0.59 in-a-million for LAKY to 5.24 in-a-million for ATKY.
- With the exception of arsenic, which is a pollutant of interest for CCKY, the remaining pollutants of interest for the Calvert City sites have cancer risk approximations less than 1.0 in-a-million. The cancer risk approximation for arsenic for CCKY is 2.64 in-a-million.
- All of the noncancer hazard approximations for the pollutants of interest for the Calvert City sites are less than an HQ of 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. For each of these sites, the pollutant with the highest noncancer hazard approximation is 1,3-butadiene, which ranged from 0.03 for ATKY to 0.52 for TVKY, which is the third highest noncancer hazard approximation among all noncancer hazard approximations calculated for the site-specific pollutants of interest (behind only BTUT and GPCO's formaldehyde noncancer hazard approximations).
- Formaldehyde, acetaldehyde, and arsenic are the only pollutants of interest for LEKY for which annual average concentrations could be calculated. The cancer risk approximation for formaldehyde (37.85 in-a-million) is an order of magnitude greater than the cancer risk approximations for the other two pollutants of interest. All of the noncancer hazard approximations for the pollutants of interest for LEKY are considerably less than an HQ of 1.0 (0.30 or less), indicating that no adverse noncancer health effects are expected from these individual pollutants, where they could be calculated.

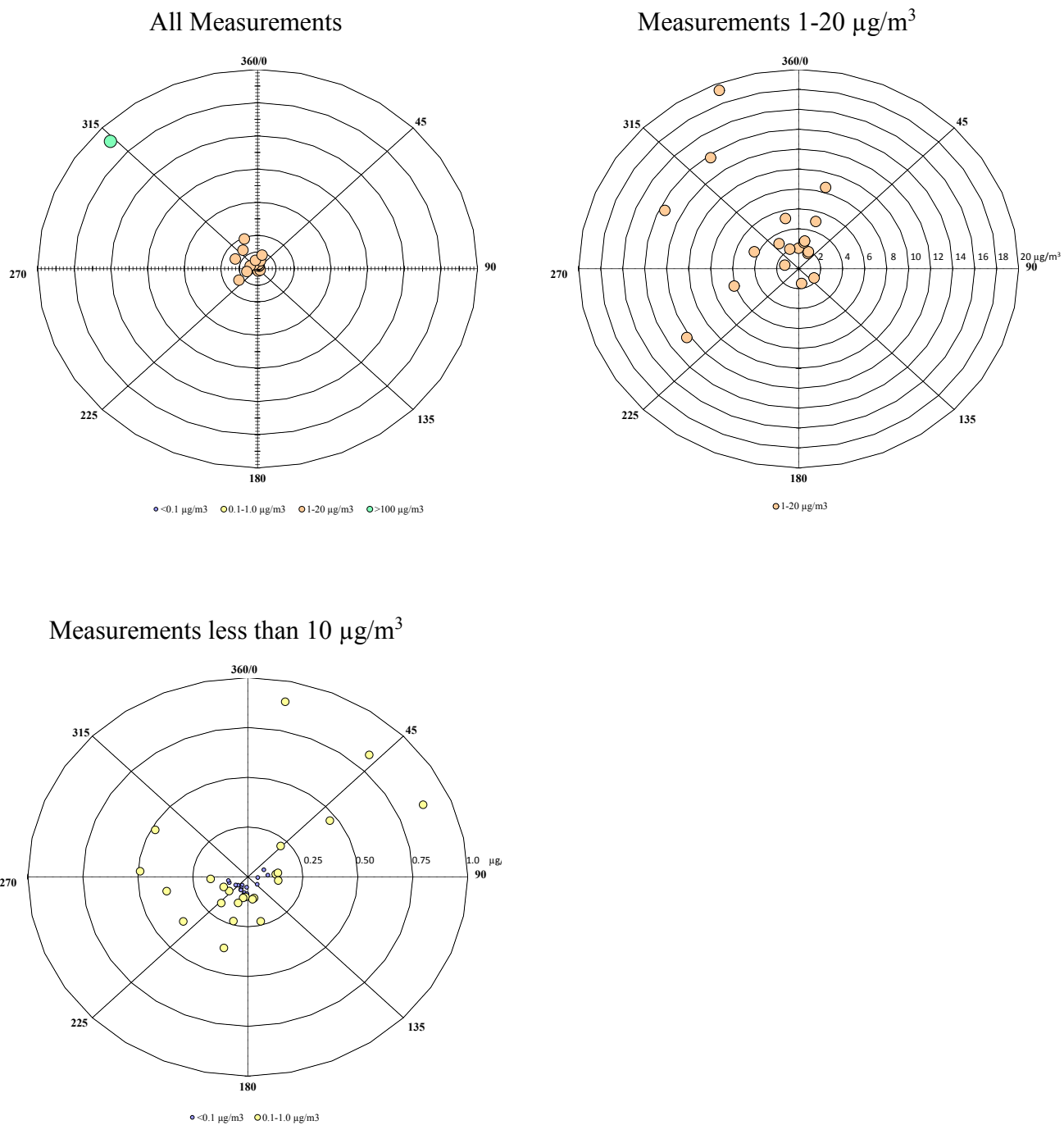
As an extension of this analysis, pollution roses were created for each of the site-specific pollutants of interest that have a cancer risk approximation greater than 75 in-a-million and/or a noncancer hazard approximation greater than 1.0, where applicable. Thus, a pollution rose was created for TVKY's 1,2-dichloroethane measurements. A pollution rose is a plot of the ambient concentration versus the wind speed and direction; the magnitude of the concentration is indicated using different colored dots and are shown in relation to the average wind direction oriented about a 16-point compass, similar to the wind roses presented in Section 14.2.3. Thus, high concentrations may be shown in relation to the direction of potential emissions sources. Hourly NWS wind observations used in this analysis were averaged (using vector averaging techniques) to compute daily wind direction averages for comparison to the 24-hour concentration data. This analysis is intended to help identify the geographical area where the emissions sources of these pollutants may have originated. Additional information regarding this analysis is also presented in Section 3.4.3.3.

Figure 14-41 presents the pollution rose for all 61 1,2-dichloroethane concentrations measured at TVKY. However, the magnitude of the maximum concentration ($111 \mu\text{g}/\text{m}^3$) is such that all of the lower concentrations are plotted nearly on top of each other. As a result, three pollution roses were created for TVKY. One that shows all measurements, one that shows all 1,2-dichloroethane measurements that fall between 1 and $20 \mu\text{g}/\text{m}^3$, and one that shows all 1,2-dichloroethane measurements less than $1 \mu\text{g}/\text{m}^3$.

Observations for Figure 14-41 include the following:

- The pollution rose with all 1,2-dichloroethane measurements plotted on it shows that the maximum 1,2-dichloroethane (shown in green) measured at TVKY is greater than $100 \mu\text{g}/\text{m}^3$ but all other measurements are less than $20 \mu\text{g}/\text{m}^3$. This maximum concentration was measured on November 18, 2013, a day with an average wind direction of roughly 315° or northwest. Individual hourly wind directions observed that day ranged from 260° (west) to 350° (north-northwest) with wind speeds ranging from 3 knots to 14 knots; in addition, calm winds were measured for six of the hourly observations.
- The pollution rose with 1,2-dichloroethane measurements ranging from $1 \mu\text{g}/\text{m}^3$ to $20 \mu\text{g}/\text{m}^3$ plotted on it shows that most of these concentrations were measured on days with average wind directions between 225° (southwest) and 45° (northeast) and are shown above the diagonal northeast-southwest line. In addition, only four of these measurements are shown in association with wind directions with a southerly component (or below the horizontal east-west line).
- The pollution rose with 1,2-dichloroethane measurements less $1 \mu\text{g}/\text{m}^3$ plotted on it shows that these concentrations were measured on days with average wind directions between 45° (northeast) and 225° (southwest) and are shown below the diagonal northeast-southwest line. In addition, only four of these measurements are shown in association with wind directions between 270° (west) and 45° (northeast), which is nearly the opposite of the previous pollution rose.

Figure 14-41. Pollution Rose for 1,2-Dichloroethane Concentrations Measured at TVKY



14.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, Tables 14-8 and 14-9 present an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 14-8 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 14-8 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 14-8 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 14-7. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 14-8. Table 14-9 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 14.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 14-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Health Department, Ashland, Kentucky (Boyd County) - ASKY					
Benzene	61.79	Coke Oven Emissions, PM	7.25E-03	Formaldehyde	29.87
Formaldehyde	20.35	Hexavalent Chromium	9.84E-04	Benzene	11.85
Ethylbenzene	13.36	Nickel, PM	6.71E-04	Carbon Tetrachloride	3.92
Acetaldehyde	11.59	Benzene	4.82E-04	Acetaldehyde	2.62
Coke Oven Emissions, PM	7.32	Formaldehyde	2.64E-04	1,2-Dichloroethane	1.95
1,3-Butadiene	3.65	2,4-Dinitrotoluene	1.96E-04	1,3-Butadiene	1.71
2,4-Dinitrotoluene	2.20	1,3-Butadiene	1.10E-04		
Tetrachloroethylene	2.00	Naphthalene	6.77E-05		
Naphthalene	1.99	Cadmium, PM	5.96E-05		
Nickel, PM	1.40	POM, Group 2b	4.51E-05		
21st and Greenup, Ashland, Kentucky (Boyd County) - ASKY-M					
Benzene	61.79	Coke Oven Emissions, PM	7.25E-03	Arsenic	5.34
Formaldehyde	20.35	Hexavalent Chromium	9.84E-04	Nickel	1.15
Ethylbenzene	13.36	Nickel, PM	6.71E-04	Cadmium	0.72
Acetaldehyde	11.59	Benzene	4.82E-04		
Coke Oven Emissions, PM	7.32	Formaldehyde	2.64E-04		
1,3-Butadiene	3.65	2,4-Dinitrotoluene	1.96E-04		
2,4-Dinitrotoluene	2.20	1,3-Butadiene	1.10E-04		
Tetrachloroethylene	2.00	Naphthalene	6.77E-05		
Naphthalene	1.99	Cadmium, PM	5.96E-05		
Nickel, PM	1.40	POM, Group 2b	4.51E-05		

Table 14-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Grayson, Kentucky (Carter County) - GLKY					
Benzene	20.12	Formaldehyde	1.78E-04	Formaldehyde	17.05
Formaldehyde	13.70	Benzene	1.57E-04	Carbon Tetrachloride	3.99
Acetaldehyde	9.15	1,3-Butadiene	6.86E-05	Benzene	3.79
Ethylbenzene	9.14	Naphthalene	5.57E-05	Arsenic	2.08
1,3-Butadiene	2.29	POM, Group 2b	3.60E-05	1,2-Dichloroethane	1.96
Naphthalene	1.64	POM, Group 2d	2.66E-05	Acetaldehyde	1.50
POM, Group 2b	0.41	Ethylbenzene	2.29E-05	1,3-Butadiene	1.24
POM, Group 2d	0.30	POM, Group 5a	2.23E-05		
POM, Group 6	0.04	Acetaldehyde	2.01E-05		
Trichloroethylene	0.03	POM, Group 6	7.36E-06		
Baskett, Kentucky (Henderson County) - BAKY					
Formaldehyde	52.75	Formaldehyde	6.86E-04	Arsenic	3.53
Benzene	42.14	Naphthalene	5.72E-04	Nickel	0.29
Acetaldehyde	27.10	POM, Group 2d	3.74E-04		
Naphthalene	16.81	Benzene	3.29E-04		
Ethylbenzene	16.17	Hexavalent Chromium	2.83E-04		
Tetrachloroethylene	6.71	Nickel, PM	2.73E-04		
1,3-Butadiene	6.59	POM, Group 2b	2.52E-04		
POM, Group 2d	4.25	1,3-Butadiene	1.98E-04		
POM, Group 2b	2.87	Acetaldehyde	5.96E-05		
Dichloromethane	0.83	Cadmium, PM	5.03E-05		

Table 14-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Atmos Energy, Calvert City, Kentucky (Marshall County) - ATKY					
Benzene	139.16	Benzene	1.09E-03	1,2-Dichloroethane	7.71
Ethylbenzene	100.03	Hexavalent Chromium	6.36E-04	Vinyl chloride	5.24
Formaldehyde	36.34	Formaldehyde	4.72E-04	Benzene	4.18
Acetaldehyde	33.61	1,3-Butadiene	4.26E-04	Carbon Tetrachloride	4.02
Vinyl chloride	30.93	Vinyl chloride	2.72E-04	1,3-Butadiene	1.98
1,3-Butadiene	14.20	Ethylbenzene	2.50E-04		
1,2-Dichloroethane	9.25	1,2-Dichloroethane	2.41E-04		
Naphthalene	3.45	POM, Group 1a	2.34E-04		
POM, Group 1a	2.66	Naphthalene	1.17E-04		
Carbon tetrachloride	2.32	Nickel, PM	7.66E-05		
Calvert City Elementary, Calvert City, Kentucky (Marshall County) - CCKY					
Benzene	139.16	Benzene	1.09E-03	1,3-Butadiene	7.80
Ethylbenzene	100.03	Hexavalent Chromium	6.36E-04	1,2-Dichloroethane	6.20
Formaldehyde	36.34	Formaldehyde	4.72E-04	Carbon Tetrachloride	4.03
Acetaldehyde	33.61	1,3-Butadiene	4.26E-04	Benzene	3.87
Vinyl chloride	30.93	Vinyl chloride	2.72E-04	Arsenic	2.64
1,3-Butadiene	14.20	Ethylbenzene	2.50E-04	Hexachloro-1,3-butadiene	0.34
1,2-Dichloroethane	9.25	1,2-Dichloroethane	2.41E-04		
Naphthalene	3.45	POM, Group 1a	2.34E-04		
POM, Group 1a	2.66	Naphthalene	1.17E-04		
Carbon tetrachloride	2.32	Nickel, PM	7.66E-05		

Table 14-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Lazy Daze, Calvert City, Kentucky (Marshall County) - LAKY					
Benzene	139.16	Benzene	1.09E-03	1,3-Butadiene	19.67
Ethylbenzene	100.03	Hexavalent Chromium	6.36E-04	1,2-Dichloroethane	18.21
Formaldehyde	36.34	Formaldehyde	4.72E-04	Benzene	4.86
Acetaldehyde	33.61	1,3-Butadiene	4.26E-04	Carbon Tetrachloride	4.07
Vinyl chloride	30.93	Vinyl chloride	2.72E-04	Vinyl chloride	0.59
1,3-Butadiene	14.20	Ethylbenzene	2.50E-04	Hexachloro-1,3-butadiene	0.41
1,2-Dichloroethane	9.25	1,2-Dichloroethane	2.41E-04		
Naphthalene	3.45	POM, Group 1a	2.34E-04		
POM, Group 1a	2.66	Naphthalene	1.17E-04		
Carbon tetrachloride	2.32	Nickel, PM	7.66E-05		
TVA Substation, Calvert City, Kentucky (Marshall County) - TVKY					
Benzene	139.16	Benzene	1.09E-03	1,2-Dichloroethane	97.42
Ethylbenzene	100.03	Hexavalent Chromium	6.36E-04	1,3-Butadiene	30.97
Formaldehyde	36.34	Formaldehyde	4.72E-04	Benzene	8.29
Acetaldehyde	33.61	1,3-Butadiene	4.26E-04	Carbon Tetrachloride	4.80
Vinyl chloride	30.93	Vinyl chloride	2.72E-04	Vinyl chloride	2.57
1,3-Butadiene	14.20	Ethylbenzene	2.50E-04	1,1,2-Trichloroethane	0.82
1,2-Dichloroethane	9.25	1,2-Dichloroethane	2.41E-04	<i>p</i> -Dichlorobenzene	0.35
Naphthalene	3.45	POM, Group 1a	2.34E-04	Hexachloro-1,3-butadiene	0.29
POM, Group 1a	2.66	Naphthalene	1.17E-04		
Carbon tetrachloride	2.32	Nickel, PM	7.66E-05		

Table 14-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Smithland, Kentucky (Livingston County) - BLKY					
Benzene	14.04	Formaldehyde	1.50E-04	1,2-Dichloroethane	33.15
Formaldehyde	11.52	Benzene	1.09E-04	1,3-Butadiene	18.98
Acetaldehyde	6.66	1,3-Butadiene	5.45E-05	Carbon Tetrachloride	6.69
Ethylbenzene	5.39	Naphthalene	2.27E-05	Benzene	5.26
1,3-Butadiene	1.82	POM, Group 2b	1.63E-05	Vinyl chloride	1.56
Naphthalene	0.67	Acetaldehyde	1.47E-05	Hexachloro-1,3-butadiene	0.40
POM, Group 2b	0.18	Ethylbenzene	1.35E-05	1,1,2-Trichloroethane	0.29
POM, Group 2d	0.15	POM, Group 2d	1.31E-05		
POM, Group 6	0.03	Nickel, PM	1.16E-05		
Trichloroethylene	0.03	POM, Group 5a	1.14E-05		
Lexington, Kentucky (Fayette County) - LEKY					
Benzene	135.46	Formaldehyde	1.20E-03	Formaldehyde	37.85
Formaldehyde	92.28	Benzene	1.06E-03	Acetaldehyde	3.27
Ethylbenzene	82.26	1,3-Butadiene	5.57E-04	Arsenic	2.93
Acetaldehyde	54.60	Naphthalene	3.50E-04		
1,3-Butadiene	18.57	POM, Group 2b	2.32E-04		
Tetrachloroethylene	13.04	Ethylbenzene	2.06E-04		
Naphthalene	10.31	POM, Group 2d	1.52E-04		
POM, Group 2b	2.63	Hexavalent Chromium	1.34E-04		
Trichloroethylene	1.94	Arsenic, PM	1.28E-04		
POM, Group 2d	1.73	Acetaldehyde	1.20E-04		

Table 14-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Health Department, Ashland, Kentucky (Boyd County) - ASKY					
Toluene	89.31	Acrolein	63,687.70	Formaldehyde	0.23
Benzene	61.79	Chlorine	45,169.74	Acetaldehyde	0.13
Xylenes	52.93	Manganese, PM	33,849.17	Benzene	0.05
Hexane	49.05	Nickel, PM	15,539.17	1,3-Butadiene	0.03
Methanol	39.10	Lead, PM	11,227.89	Carbon Tetrachloride	0.01
Hydrochloric acid	27.65	Cadmium, PM	3,311.70	1,2-Dichloroethane	<0.01
Formaldehyde	20.35	Formaldehyde	2,076.07		
Ethylbenzene	13.36	Benzene	2,059.62		
Acetaldehyde	11.59	1,3-Butadiene	1,826.21		
Manganese, PM	10.15	Hydrochloric acid	1,382.51		
21st and Greenup, Ashland, Kentucky (Boyd County) - ASKY-M					
Toluene	89.31	Acrolein	63,687.70	Arsenic	0.08
Benzene	61.79	Chlorine	45,169.74	Manganese	0.07
Xylenes	52.93	Manganese, PM	33,849.17	Lead	0.06
Hexane	49.05	Nickel, PM	15,539.17	Cadmium	0.04
Methanol	39.10	Lead, PM	11,227.89	Nickel	0.03
Hydrochloric acid	27.65	Cadmium, PM	3,311.70		
Formaldehyde	20.35	Formaldehyde	2,076.07		
Ethylbenzene	13.36	Benzene	2,059.62		
Acetaldehyde	11.59	1,3-Butadiene	1,826.21		
Manganese, PM	10.15	Hydrochloric acid	1,382.51		

Table 14-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Grayson, Kentucky (Carter County) - GLKY					
Toluene	58.15	Acrolein	45,189.54	Formaldehyde	0.13
Xylenes	35.59	Formaldehyde	1,397.58	Acetaldehyde	0.08
Hexane	25.95	Cyanide Compounds, gas	1,278.36	Arsenic	0.03
Benzene	20.12	1,3-Butadiene	1,144.01	1,3-Butadiene	0.02
Methanol	15.68	Acetaldehyde	1,016.31	Benzene	0.02
Formaldehyde	13.70	Benzene	670.52	Carbon Tetrachloride	0.01
Acetaldehyde	9.15	Naphthalene	545.72	1,2-Dichloroethane	<0.01
Ethylbenzene	9.14	Xylenes	355.95		
Ethylene glycol	5.50	Arsenic, PM	91.58		
1,3-Butadiene	2.29	Propionaldehyde	84.60		
Baskett, Kentucky (Henderson County) - BAKY					
Carbonyl sulfide	128.78	Acrolein	76,864.06	Arsenic	0.05
Toluene	112.00	Manganese, PM	7,205.03	Nickel	0.01
Xylenes	78.62	Nickel, PM	6,326.84		
Hexane	54.97	Naphthalene	5,604.26		
Formaldehyde	52.75	Formaldehyde	5,383.11		
Benzene	42.14	1,3-Butadiene	3,295.39		
Methanol	28.37	Chlorine	3,245.91		
Acetaldehyde	27.10	Acetaldehyde	3,010.82		
Naphthalene	16.81	Cadmium, PM	2,795.50		
Ethylbenzene	16.17	4,4'-Methylenediphenyl diisocyanate, gas	2,483.57		

Table 14-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Atmos Energy, Calvert City, Kentucky (Marshall County) - ATKY					
Methanol	677.58	Chlorine	210,803.93	1,3-Butadiene	0.03
Xylenes	522.49	Acrolein	125,961.44	Benzene	0.02
Toluene	480.91	1,3-Butadiene	7,098.77	Carbon Tetrachloride	0.01
Benzene	139.16	Xylenes	5,224.89	Vinyl chloride	0.01
Hexane	100.70	Benzene	4,638.60	1,2-Dichloroethane	<0.01
Ethylbenzene	100.03	Hydrochloric acid	4,173.99		
Hydrochloric acid	83.48	Acetaldehyde	3,734.64		
Vinyl acetate	73.28	Formaldehyde	3,708.16		
Formaldehyde	36.34	Acrylic acid	2,916.21		
Acetaldehyde	33.61	Nickel, PM	1,773.75		
Calvert City Elementary, Calvert City, Kentucky (Marshall County) - CCKY					
Methanol	677.58	Chlorine	210,803.93	1,3-Butadiene	0.13
Xylenes	522.49	Acrolein	125,961.44	Arsenic	0.04
Toluene	480.91	1,3-Butadiene	7,098.77	Benzene	0.02
Benzene	139.16	Xylenes	5,224.89	Carbon Tetrachloride	0.01
Hexane	100.70	Benzene	4,638.60	Hexachloro-1,3-butadiene	0.00
Ethylbenzene	100.03	Hydrochloric acid	4,173.99	1,2-Dichloroethane	<0.01
Hydrochloric acid	83.48	Acetaldehyde	3,734.64		
Vinyl acetate	73.28	Formaldehyde	3,708.16		
Formaldehyde	36.34	Acrylic acid	2,916.21		
Acetaldehyde	33.61	Nickel, PM	1,773.75		

Table 14-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Lazy Daze, Calvert City, Kentucky (Marshall County) - LAKY					
Methanol	677.58	Chlorine	210,803.93	1,3-Butadiene	0.33
Xylenes	522.49	Acrolein	125,961.44	Benzene	0.02
Toluene	480.91	1,3-Butadiene	7,098.77	Carbon Tetrachloride	0.01
Benzene	139.16	Xylenes	5,224.89	Vinyl chloride	<0.01
Hexane	100.70	Benzene	4,638.60	1,2-Dichloroethane	<0.01
Ethylbenzene	100.03	Hydrochloric acid	4,173.99	Hexachloro-1,3-butadiene	<0.01
Hydrochloric acid	83.48	Acetaldehyde	3,734.64		
Vinyl acetate	73.28	Formaldehyde	3,708.16		
Formaldehyde	36.34	Acrylic acid	2,916.21		
Acetaldehyde	33.61	Nickel, PM	1,773.75		
TVA Substation, Calvert City, Kentucky (Marshall County) - TVKY					
Methanol	677.58	Chlorine	210,803.93	1,3-Butadiene	0.52
Xylenes	522.49	Acrolein	125,961.44	Benzene	0.04
Toluene	480.91	1,3-Butadiene	7,098.77	Carbon Tetrachloride	0.01
Benzene	139.16	Xylenes	5,224.89	Vinyl chloride	<0.01
Hexane	100.70	Benzene	4,638.60	1,2-Dichloroethane	<0.01
Ethylbenzene	100.03	Hydrochloric acid	4,173.99	Hexachloro-1,3-butadiene	<0.01
Hydrochloric acid	83.48	Acetaldehyde	3,734.64	1,1,2-Trichloroethane	<0.01
Vinyl acetate	73.28	Formaldehyde	3,708.16	p-Dichlorobenzene	<0.01
Formaldehyde	36.34	Acrylic acid	2,916.21		
Acetaldehyde	33.61	Nickel, PM	1,773.75		

Table 14-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Smithland, Kentucky (Livingston County) - BLKY					
Toluene	43.04	Acrolein	20,492.52	1,3-Butadiene	0.32
Xylenes	38.50	Formaldehyde	1,175.61	Benzene	0.02
Benzene	14.04	1,3-Butadiene	909.04	Carbon Tetrachloride	0.01
Hexane	12.08	Acetaldehyde	740.44	Vinyl chloride	<0.01
Formaldehyde	11.52	Cyanide Compounds, gas	527.46	1,2-Dichloroethane	<0.01
Acetaldehyde	6.66	Benzene	467.89	Hexachloro-1,3-butadiene	<0.01
Ethylbenzene	5.39	Xylenes	384.98	1,1,2-Trichloroethane	<0.01
Methanol	5.38	Nickel, PM	268.68		
Ethylene glycol	1.89	Naphthalene	222.51		
1,3-Butadiene	1.82	Manganese, PM	201.76		
Lexington, Kentucky (Fayette County) - LEKY					
Toluene	487.75	Acrolein	277,725.18	Formaldehyde	0.30
Xylenes	315.94	Formaldehyde	9,416.72	Acetaldehyde	0.17
Hexane	246.40	1,3-Butadiene	9,286.39	Arsenic	0.05
Methanol	176.71	Acetaldehyde	6,066.40		
Benzene	135.46	Benzene	4,515.24		
Formaldehyde	92.28	Naphthalene	3,436.18		
Ethylbenzene	82.26	Xylenes	3,159.41		
Ethylene glycol	59.08	Hexamethylene-1,6-diisocyanate, gas	2,051.30		
Acetaldehyde	54.60	Arsenic, PM	1,982.63		
Methyl isobutyl ketone	29.90	4,4'-Methylenediphenyl diisocyanate, gas	1,757.48		

Observations from Table 14-8 include the following:

- Among the Kentucky counties with monitoring sites, emissions (for pollutants with cancer UREs) are highest in Fayette County (LEKY) and Marshall County (Calvert City) and lowest in Livingston County (BLKY) and Carter County (GLKY).
- Benzene, formaldehyde, ethylbenzene are the highest emitted pollutants with cancer UREs in Boyd County, where the Ashland sites are located. Coke oven emissions, hexavalent chromium, and nickel are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Boyd County. Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Boyd County.
- For ASKY, formaldehyde, benzene, and 1,3-butadiene are among the pollutants with the highest cancer risk approximations and appear on both emissions-based lists. Acetaldehyde, which has the fourth highest cancer risk approximation for ASKY, has the fourth highest emissions for Boyd County but is not among the pollutants with the highest toxicity-weighted emissions (acetaldehyde ranks 13th for toxicity-weighted emissions). Carbon tetrachloride and 1,2-dichloroethane, the other pollutants of interest for ASKY, appear on neither emissions-based list.
- Nickel is the only pollutant of interest for ASKY-M to appear on both emissions-based lists for Boyd County. While cadmium ranks ninth in Boyd County for its toxicity-weighted emissions, it is not among the highest emitted (ranking 18th). Arsenic, which has the highest cancer risk approximation for ASKY-M, appears on neither emissions-based list (ranking 24th for total emissions and 15th for toxicity-weighted emissions).
- Benzene, formaldehyde, acetaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Carter County, where GLKY is located. Formaldehyde, benzene, 1,3-butadiene, and naphthalene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for this county. Nine of the highest emitted pollutants also have the highest toxicity-weighted emissions for Carter County (all of which are sampled for at GLKY).
- Formaldehyde has the highest cancer risk approximation for GLKY, and ranks first for its toxicity-weighted emissions and second for its total emissions in Table 14-8. Benzene, 1,3-butadiene, and acetaldehyde also appear on all three lists. The three remaining pollutants of interest appear on neither emissions-based list.
- Three POM Groups appear among the highest emitted pollutants in Carter County (POM, Groups 2b, 2d, and 6) and four POM Groups appear among the pollutants with the highest toxicity-weighted emissions (POM, Groups 2b, 2d, 5a, and 6). Many of the PAHs sampled using Method TO-13 are part of POM, Groups 2b, 2d, 5a, and 6. However, none of these pollutants failed screens for GLKY.
- Formaldehyde, benzene, and acetaldehyde are the highest emitted pollutants with cancer UREs in Henderson County, where BAKY is located. Formaldehyde, naphthalene, and POM Group 2d are the pollutants with the highest toxicity-weighted

emissions (of the pollutants with cancer UREs) for this county. Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Henderson County.

- Arsenic and nickel are the only pollutants of interest for BAKY. Arsenic appears on neither emissions-based list for Henderson County (arsenic ranks 22nd for total emissions and 13th for toxicity-weighted emissions). Nickel ranks sixth for its toxicity-weighted emissions but is not among the highest emitted (ranking 11th for total emissions). Cadmium is another speciated metal that appears among those with the highest toxicity-weighted emissions for Henderson County (ranking 10th), but it is not among the highest emitted (ranking 15th). Cadmium did not fail any screens for BAKY.
- Benzene, ethylbenzene, and formaldehyde are the highest emitted pollutants with cancer UREs in Marshall County, where four of the five Calvert City sites are located. Benzene, hexavalent chromium, and formaldehyde are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for this county. Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Marshall County.
- Marshall County is the only county with NMP sites for which vinyl chloride appears among the highest emitted pollutants. The quantity of vinyl chloride emitted in Marshall County (31 tpy) is the highest emissions for this pollutant among NMP counties and is twice the quantity of the next highest emissions (16 tpy in Harris County, Texas). This is also true for carbon tetrachloride. There are only three counties with NMP sites that have carbon tetrachloride emissions greater than 1 tpy, Marshall County, Kentucky (2.32 tpy), Harris County, Texas (1.26 tpy), and Harrison County, Texas (1.08 tpy). Marshall County is also the only county with NMP sites for which 1,2-dichloroethane appears among the highest emitted pollutants. The quantity of 1,2-dichloroethane emitted in Marshall County (9.25 tpy) is the second highest emissions for this pollutant among NMP sites, behind only Harris County, Texas (16 tpy).
- Marshall County is the only county for which vinyl chloride and 1,2-dichloroethane appear among the pollutants with the highest toxicity-weighted emissions.
- Most of the VOC pollutants of interest for the Calvert City sites for which cancer risk approximations could be calculated appear on both emissions-based lists for Marshall County. Carbon tetrachloride is an exception, appearing among the highest emitted but not those with the highest toxicity-weighted emissions. Hexachloro-1,3-butadiene, 1,1,2-trichloroethane, and *p*-dichlorobenzene, which are pollutants of interest for at least one of the four Marshall County sites, do not appear on either emissions-based list.
- Arsenic is the only pollutant of interest among the speciated metals sampled for at CCKY. Arsenic appears on neither emissions-based list for Marshall County (arsenic ranks 25th for total emissions and 13th for toxicity-weighted emissions).

- Benzene, formaldehyde, and acetaldehyde are the highest emitted pollutants with cancer UREs in Livingston County, where BLKY is located. Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for this county. Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Livingston County.
- Few of BLKY's pollutants of interest appear among the pollutants on the emissions-based lists for Livingston County (only 1,3-butadiene and benzene).
- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Fayette County, where LEKY is located. Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for this county. Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Fayette County.
- Cancer risk approximations could only be calculated for formaldehyde, acetaldehyde, and arsenic. All three of these pollutant appear among those with the highest toxicity-weighted emissions, and both carbonyl compounds appear among the highest emitted (with arsenic ranking 22nd for total emissions).

Observations from Table 14-9 include the following:

- Among the Kentucky counties with monitoring sites, emissions (for pollutants with noncancer RfCs) are highest in Marshall County (Calvert City) and Fayette County (LEKY) and lowest in Livingston County (BLKY).
- Toluene, benzene, and xylenes are the highest emitted pollutants with noncancer RfCs in Boyd County. Acrolein, chlorine, and manganese are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for Boyd County. Four of the highest emitted pollutants also have the highest toxicity-weighted emissions for Boyd County.
- Although acrolein was sampled for at ASKY, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. Acrolein does not appear among Boyd County's highest emitted pollutants.
- Of the pollutants of interest for which noncancer hazard approximations could be calculate for ASKY, two (formaldehyde and benzene) also appear on both emissions-based lists. Acetaldehyde, the pollutant with the second-highest noncancer hazard approximation for ASKY, is among the highest emitted but not among those with the highest toxicity-weighted emissions. 1,3-Butadiene, the pollutant with the fourth-highest noncancer hazard approximation for ASKY, is among those with the highest toxicity-weighted emissions but is not among the highest emitted.
- Nonancer hazard approximations could be calculated for all five metal pollutants of interest for ASKY-M. Manganese, which has the second highest nonancer hazard

approximation, also has the third highest toxicity-weighted emissions and tenth highest total emissions for Boyd County. Nickel, lead, and cadmium are also among the pollutants with the highest toxicity-weighted emissions, although none of these are among the highest emitted in Boyd County.

- Toluene, xylenes, and hexane are the highest emitted pollutants with noncancer RfCs in Carter County. Acrolein, formaldehyde, and cyanide compounds (gaseous) are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for Carter County. Five of the highest emitted pollutants also have the highest toxicity-weighted emissions for Carter County.
- Although acrolein was sampled for at GLKY, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. Acrolein does not appear among Carter County's highest emitted pollutants.
- Formaldehyde and acetaldehyde have the highest noncancer hazard approximations for GLKY and appear on both emissions-based lists. Benzene and 1,3-butadiene also appears on all three lists. Arsenic has the third highest noncancer hazard approximation for GLKY and is among the pollutants with the highest toxicity-weighted emissions but is not among the highest emitted in Carter County (its emissions rank 32nd). Carbon tetrachloride and 1,2-dichloroethane, the remaining two pollutants of interest for GLKY, appear on neither emissions-based list for Carter County.
- Carbonyl sulfide, toluene, and xylenes are the highest emitted pollutants with noncancer RfCs in Henderson County. Henderson County is the only county with an NMP site for which carbonyl sulfide appears among the 10 highest emitted pollutants. Acrolein, manganese, and nickel are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for this county. Three of the highest emitted pollutants also have the highest toxicity-weighted emissions for Henderson County.
- Arsenic and nickel are the pollutants of interest for BAKY. Nickel has the third highest toxicity-weighted emissions for Henderson County but is not among the highest emitted (ranking 27th among pollutants with noncancer RfCs). Arsenic appears on neither emissions-based list (ranking 44th for total emissions and 18th for toxicity-weighted emissions). Manganese and cadmium, which were sampled for at BAKY but did not fail any screens, rank second and ninth, respectively for their toxicity-weighted emissions for Henderson County.
- Methanol, xylenes, toluene are the highest emitted pollutants with noncancer RfCs in Marshall County. Chlorine, acrolein, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for this county. This is the only county with an NMP site for which acrolein was not the pollutant with the highest toxicity-weighted emissions. Five of the highest emitted pollutants also have the highest toxicity-weighted emissions for Marshall County.

- Benzene is the only pollutant of interest for the Calvert City sites to appear on all three lists. 1,3-Butadiene has the highest noncancer hazard approximation for all four Calvert City sites located in Marshall County (as well as the one located in Livingston County). This pollutant has the third highest toxicity-weighted emissions but is not among the highest emitted (ranking 14th). None of the other VOC pollutants of interest for the Calvert City sites appear on either emissions-based list for Marshall County. This is also true for arsenic, the only other pollutant of interest for CCKY.
- Toluene, xylenes, and benzene are the highest emitted pollutants with noncancer RfCs in Livingston County. Acrolein, formaldehyde, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for this county. Five of the highest emitted pollutants also have the highest toxicity-weighted emissions for Livingston County.
- Although acrolein was sampled for at BLKY, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. Acrolein does not appear among Livingston County's highest emitted pollutants.
- 1,3-Butadiene and benzene have the highest noncancer hazard approximations for BLKY. These pollutants appear on both emissions-based lists for Livingston County but are the only pollutants of interest for BLKY to do so.
- Toluene, xylenes, and hexane are the highest emitted pollutants with noncancer RfCs in Fayette County. Acrolein, formaldehyde, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for this county. Four of the highest emitted pollutants also have the highest toxicity-weighted emissions for Fayette County.
- Although acrolein was sampled for at LEKY, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. Acrolein does not appear among Fayette County's highest emitted pollutants.
- Noncancer hazard approximations could only be calculated for formaldehyde, acetaldehyde, and arsenic. All three of these pollutant appear among those with the highest toxicity-weighted emissions, and both carbonyl compounds also appear among the highest emitted (with arsenic ranking 42nd for total emissions).

14.6 Summary of the 2013 Monitoring Data for the Kentucky Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *Eight monitoring sites sampled for VOCs; five monitoring sites sampled for PM₁₀ metals; three monitoring sites sampled for carbonyl compounds; PAHs and hexavalent chromium were also sampled for at GLKY (although hexavalent chromium sampling was discontinued in June 2013).*
- ❖ *The number of pollutants failing screens for the Kentucky sites varies from two (BAKY) to 12 (GLKY, TVKY, and LEKY).*
- ❖ *ASKY-M had the highest annual average concentrations of arsenic and nickel among NMP sites sampling PM₁₀ metals. Three additional Kentucky sites (BAKY, LEKY, and CCKY) were among the sites with the highest annual average concentrations of arsenic and BAKY was also among the sites with the highest annual average concentrations of nickel.*
- ❖ *The maximum benzene concentration measured across the program was measured at ASKY, which had the fourth highest annual average concentration of benzene among NMP sites sampling this pollutant.*
- ❖ *Some of the highest concentrations of VOCs were measured at the Calvert City sites, particularly vinyl chloride, carbon tetrachloride, 1,3-butadiene, and 1,2-dichloroethane.*
- ❖ *The cancer risk approximation 1,2-dichloroethane for TVKY is the second highest among cancer risk approximations calculated for all site-specific pollutants of interest.*

15.0 Site in Massachusetts

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Massachusetts, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

15.1 Site Characterization

This section characterizes the BOMA monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The BOMA monitoring site is located in Boston. Figure 15-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 15-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 15-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 15-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 15-1. Boston, Massachusetts (BOMA) Monitoring Site

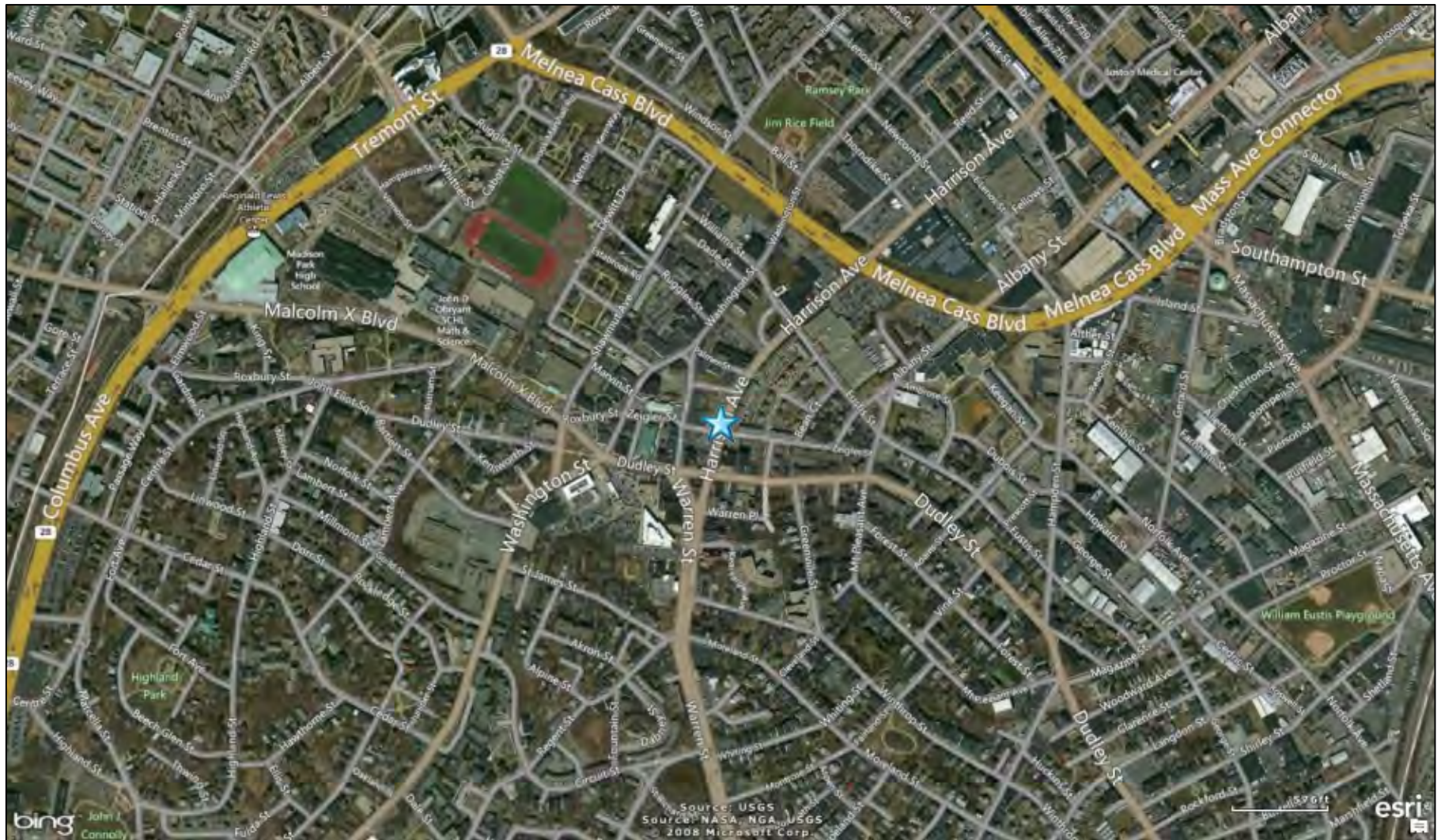


Figure 15-2. NEI Point Sources Located Within 10 Miles of BOMA

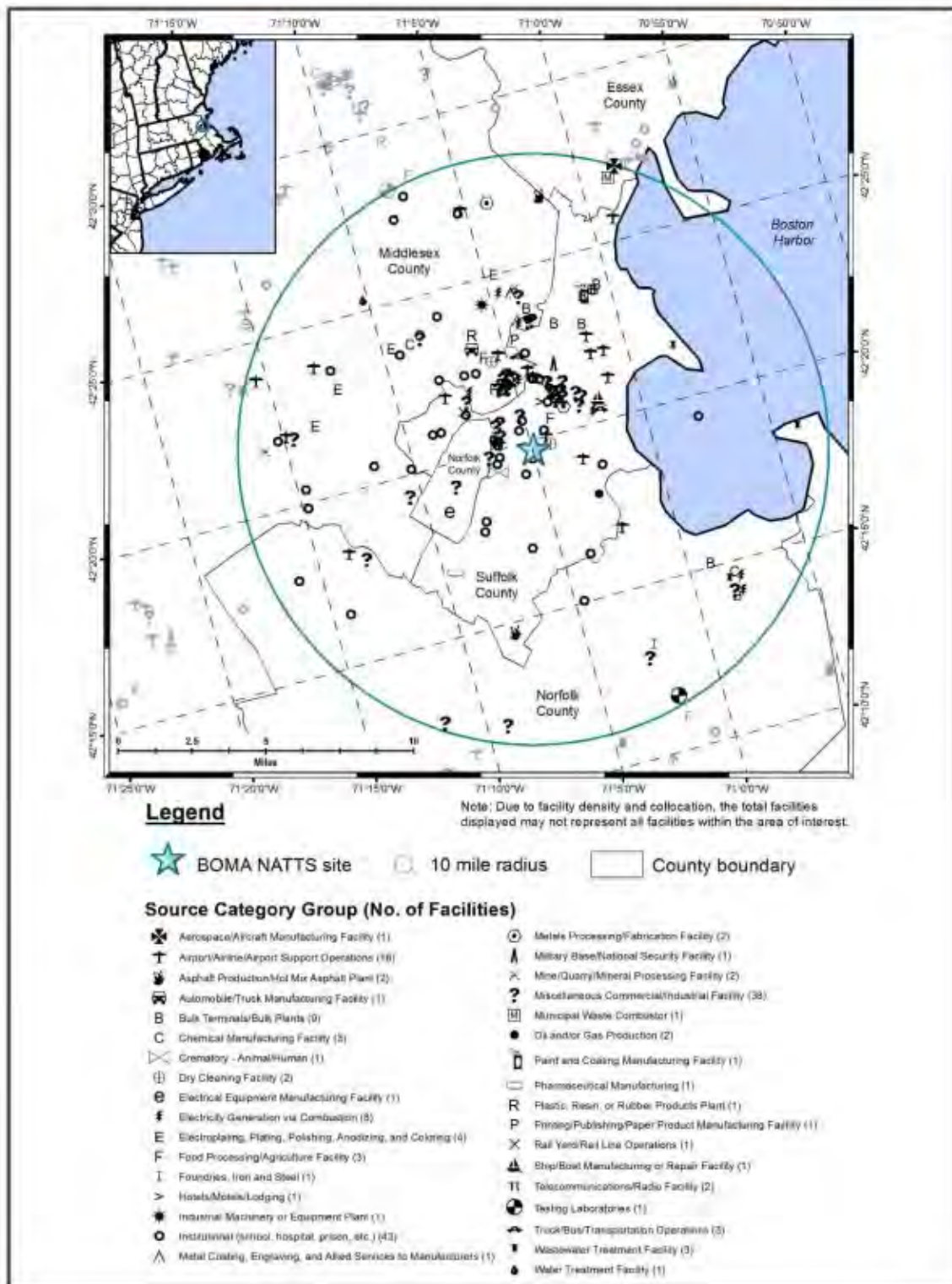


Table 15-1. Geographical Information for the Massachusetts Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>BOMA</i>	25-025-0042	Boston	Suffolk	Boston-Cambridge-Newton, MA-NH	42.3295, -71.0826	Commercial	Urban/City Center	CO, VOCs, SO ₂ , NO, NO ₂ , NO _x , NO _y , O ₃ , PM ₁₀ , PAMS/NMOCs, Carbonyl compounds, Meteorological parameters, Black carbon, PM coarse, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for this site (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The BOMA monitoring site is located at Dudley Square in Roxbury, a southwest neighborhood of Boston and is the Roxbury NATTS site. The surrounding area is commercial as well as residential, as shown in Figure 15-1. Immediately to the east of the monitoring site are town homes, to the north is a parking lot and to the west are commercial properties. The original purpose for the location of this site was to measure population exposure to a city bus terminal located another block west of the monitoring site. In recent years, the buses servicing the area were converted to compressed natural gas (CNG). The monitoring site is 1.3 miles south of I-90 and 1 mile west of I-93. As Figure 15-2 shows, BOMA is located near a large number of point sources, with a high density of sources located a few miles to the west, northwest, and north of the site. The source category with the highest number of emissions sources surrounding BOMA is the institution category, which includes schools, hospitals, and prisons. There are also numerous airport and airport support operations, which include airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; bulk terminals and bulk plants; and electricity generating units (via combustion). Sources located within 1 mile of BOMA include several hospitals, a heliport at one of the hospitals, a university, and a dry cleaning facility. Figure 15-2 shows that BOMA is located less than 2 miles from the shoreline (Dorchester Bay).

Table 15-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Massachusetts monitoring site. Table 15-2 includes both county-level population and vehicle registration information. Table 15-2 also contains traffic volume information for BOMA as well as the location for which the traffic volume was obtained. Additionally, Table 15-2 presents the county-level daily VMT for Suffolk County.

Table 15-2. Population, Motor Vehicle, and Traffic Information for the Massachusetts Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
BOMA	Suffolk	755,503	393,252	27,654	Melnea Cass Blvd near Shawmut Ave	10,963,634

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2013 data (MA RMV, 2014)

³AADT reflects 2010 data (MA DOT, 2010)

⁴County-level VMT reflects 2013 data (MA DOT, 2014)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 15-2 include the following:

- The Suffolk County population is in the middle of the range, ranking 18th among other counties with NMP sites.
- The Suffolk County vehicle registration is also in the middle of the range, ranking 26th among other counties with NMP sites.
- The traffic volume experienced near BOMA is in the middle of the range compared to other NMP sites. The traffic estimate provided is for Melnea Cass Boulevard near Shawmut Avenue.
- The daily VMT for Suffolk County is also in the middle of the range compared to other counties with NMP sites. The VMT for Suffolk County ranks 25th.

15.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Massachusetts on sample days, as well as over the course of the year.

15.2.1 Climate Summary

Boston's New England location ensures that the city experiences a fairly active weather pattern. Storm systems frequently track across the region, bringing ample precipitation to the area. The proximity to the Atlantic Ocean helps moderate temperatures, both in the summer and the winter, while at the same time allowing winds to gust higher than they would farther inland. Winds generally flow from the northwest in the winter and southwest in the summer. Coastal storm systems called "Nor'easters," strong low pressure systems that produce heavy rain or snow and winds up to hurricane strength along the Mid-Atlantic and northeast coastal states, often produce the heaviest snowfalls for the area. This coastal location may also be affected by tropical systems, approximately one every 5 years on average (Wood, 2004; NCDC, 2015).

15.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Massachusetts monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station to BOMA is located at Logan International Airport (WBAN 14739). Additional information about the Logan Airport weather station, such as the distance between the site and the weather station, is provided in Table 15-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 15-3. Average Meteorological Conditions near the Massachusetts Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Boston, Massachusetts – BOMA									
Logan International Airport 14739 (42.36, -71.01)	4.3 miles 60° (ENE)	Sample Day (63)	58.5 ± 4.7	51.8 ± 4.4	39.5 ± 4.7	46.3 ± 4.1	65.7 ± 3.8	1016.7 ± 1.8	9.3 ± 0.8
		2013	58.9 ± 1.9	51.8 ± 1.8	39.2 ± 2.0	46.3 ± 1.7	65.1 ± 1.6	1016.6 ± 0.8	9.1 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 15-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 15-3 is the 95 percent confidence interval for each parameter. As shown in Table 15-3, average meteorological conditions on sample days are very similar to conditions experienced throughout 2013. BOMA is among the windier locations with a NMP site, with an average scalar wind speed around 9 knots.

15.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at Logan International Airport near BOMA were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

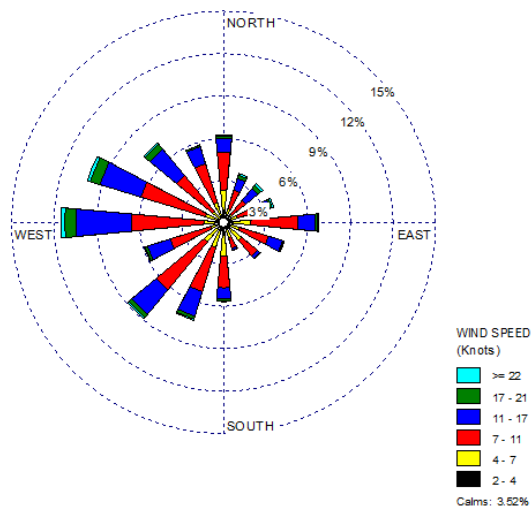
Figure 15-3 presents a map showing the distance between the weather station and BOMA, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 15-3 also presents three different wind roses for the BOMA monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 15-3. Wind Roses for the Logan International Airport Weather Station near BOMA

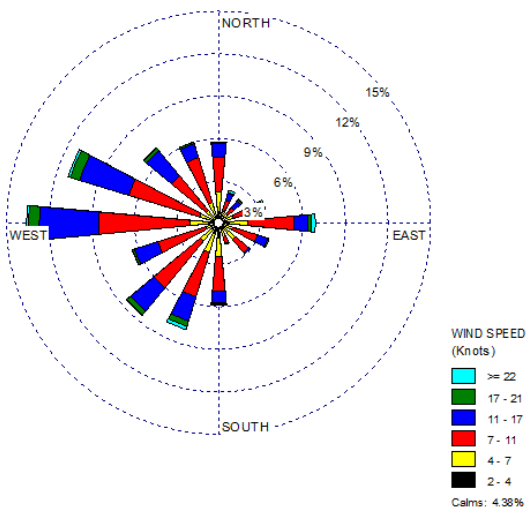
Location of BOMA and Weather Station



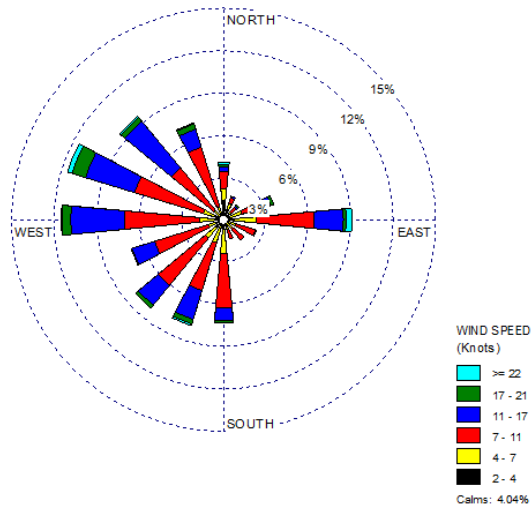
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 15-3 for BOMA include the following:

- The Logan International Airport weather station is located 4.3 miles east-northeast of BOMA. Note that the airport is located on a peninsula in Boston Harbor with downtown Boston to the west, Chelsea to the north, and Winthrop to the east, while the BOMA monitoring site is located west of South Boston and farther inland (less than 2 miles from the nearest coastline).
- The historical wind rose shows that calm winds (those less than or equal to 2 knots) account for less than 4 percent of wind observations. Winds with a westerly component (south-southwest to north-northwest) make up the majority (more than 60 percent) of winds greater than 2 knots, with westerly and west-northwesterly winds observed the most.
- The wind patterns shown on the 2013 wind rose resemble the historical wind patterns, indicating that wind conditions during 2013 were typical of conditions experienced historically near BOMA. Westerly and west-northwesterly winds account for an even higher percentages of wind observations in 2013.
- The sample day wind patterns generally resemble the full-year and historical wind patterns, although the percentage of westerly, west-northwesterly, and northwesterly winds observed was more similar, with each direction accounting for between 9 percent and 11 percent of observations. The percentage of easterly winds was also higher on sample days while the number of northerly wind observations was lower.

15.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the Massachusetts monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 15-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 15-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. PM₁₀ metals, PAHs, and hexavalent chromium were sampled for at BOMA.

Table 15-4. Risk-Based Screening Results for the Massachusetts Monitoring Site

Pollutant	Screening Value ($\mu\text{g}/\text{m}^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Boston, Massachusetts - BOMA						
Naphthalene	0.029	54	61	88.52	46.96	46.96
Arsenic (PM ₁₀)	0.00023	47	61	77.05	40.87	87.83
Nickel (PM ₁₀)	0.0021	9	61	14.75	7.83	95.65
Hexavalent Chromium	0.000083	2	14	14.29	1.74	97.39
Acenaphthene	0.011	1	61	1.64	0.87	98.26
Benzo(a)pyrene	0.00057	1	61	1.64	0.87	99.13
Fluorene	0.011	1	57	1.75	0.87	100.00
Total		115	376	30.59		

Observations from Table 15-4 include the following:

- Seven pollutants failed at least one screen for BOMA; approximately 31 percent of concentrations for these seven pollutants were greater than their associated risk screening value (or failed screens).
- Most of the pollutants that failed screens were detected in all or most of the valid samples collected at BOMA, hexavalent chromium being the exception. However, hexavalent chromium sampling was discontinued at BOMA at the end of June 2013.
- Three pollutants contributed to 95 percent of failed screens for BOMA and therefore were identified as pollutants of interest for this site. These include two PM₁₀ metals (arsenic and nickel) and one PAH (naphthalene).
- Naphthalene and arsenic each account for more than 40 percent of the total failed screens for BOMA while nickel accounts for just less than 8 percent of failed screens.

15.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Massachusetts monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically to illustrate how each site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at BOMA are provided in Appendices M through O.

15.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for BOMA, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for BOMA are presented in Table 15-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 15-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Massachusetts Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
Boston, Massachusetts – BOMA						
Arsenic (PM ₁₀)	61/61	0.39 ± 0.13	0.50 ± 0.20	0.58 ± 0.16	0.46 ± 0.18	0.48 ± 0.08
Naphthalene	61/61	44.21 ± 13.33	54.69 ± 16.97	57.50 ± 9.87	60.48 ± 17.09	54.32 ± 7.09
Nickel (PM ₁₀)	61/61	1.23 ± 0.21	1.25 ± 0.31	1.80 ± 0.65	1.40 ± 0.57	1.42 ± 0.23

Observations for BOMA from Table 15-5 include the following:

- Naphthalene is the pollutant with the highest annual average concentration (54.32 ± 7.09 ng/m³). The annual average concentrations for the remaining pollutants of interest are at least an order of magnitude lower.

- Concentrations of naphthalene measured at BOMA range from 19 ng/m³ to 164 ng/m³. Concentrations tended to be lowest in the first quarter and highest in the fourth quarter, based on the quarterly averages, although the differences are not statistically significant. Four naphthalene concentrations greater than 100 ng/m³ were measured at BOMA: one in January (101 ng/m³), one in May (157 ng/m³), and two in October (103 ng/m³ and 164 ng/m³).
- Concentrations of arsenic measured at BOMA range from 0.06 ng/m³ to 1.41 ng/m³. The maximum concentration of arsenic was measured on the same day as the maximum naphthalene concentration, October 31, 2013. The quarterly average concentrations do not vary significantly across the calendar quarters. Four arsenic concentrations greater than 1 ng/m³ were measured at BOMA: one in April (1.38 ng/m³), one in May (1.32 ng/m³), one in September (1.16 ng/m³), and one in October (1.41 ng/m³).
- Concentrations of nickel measured at BOMA range from 0.43 ng/m³ to 5.26 ng/m³. The third and fourth quarterly averages have more variability associated with their individual measurements, as their confidence intervals are roughly twice the confidence intervals for the first and second quarterly averages. The five highest concentrations (those greater than 2.5 ng/m³) were measured at BOMA between July and December and of the 10 measurements greater than 2 ng/m³, seven were measured during the second half of the year.
- Table 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level speciated metals pollutants of interest. This table shows that BOMA has the fifth highest annual average concentrations of nickel among NMP sites sampling PM₁₀ metals.

15.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 15-4 for BOMA. Figures 15-4 through 15-6 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 15-4. Program vs. Site-Specific Average Arsenic (PM₁₀) Concentration

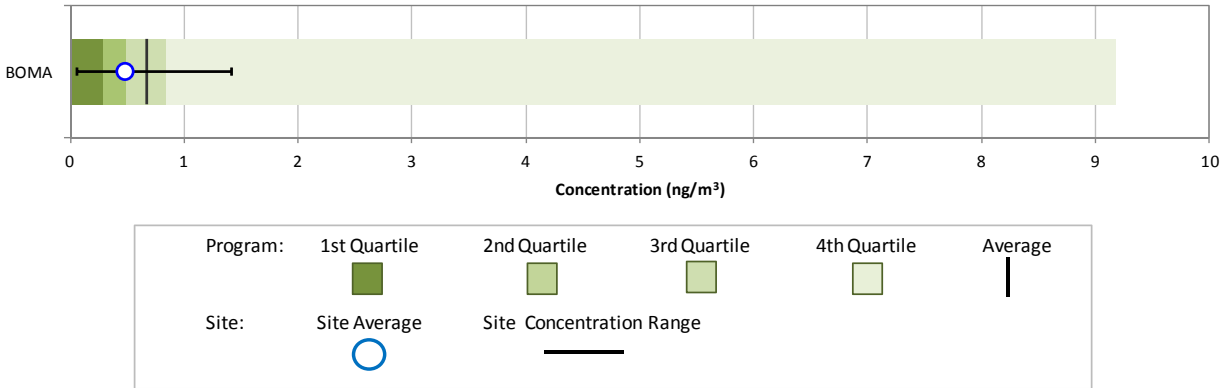


Figure 15-5. Program vs. Site-Specific Average Naphthalene Concentration

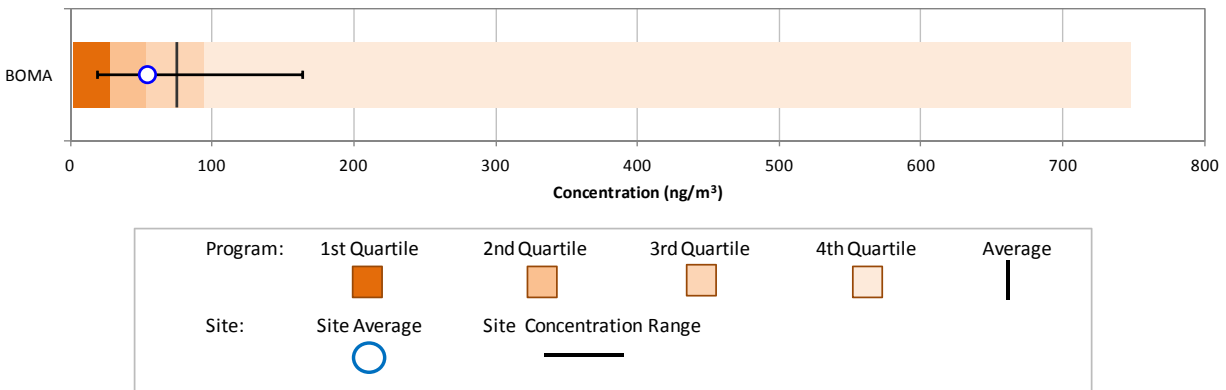
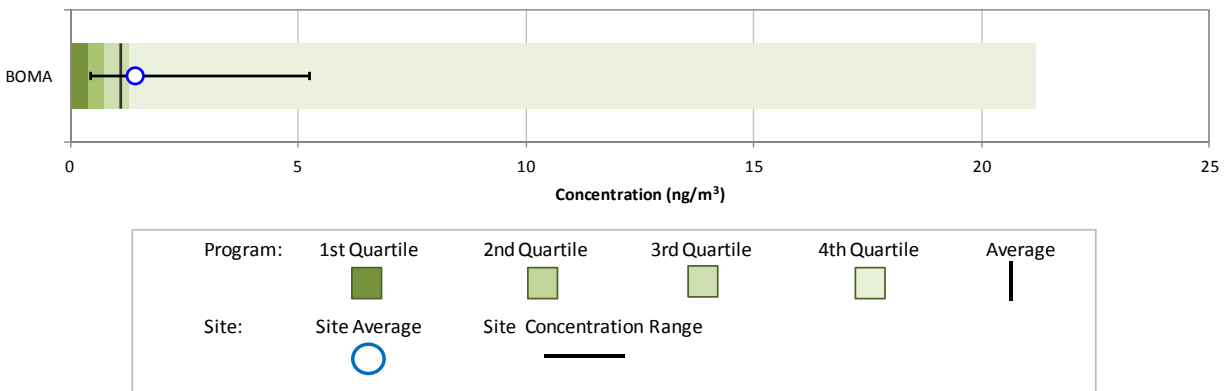


Figure 15-6. Program vs. Site-Specific Average Nickel (PM₁₀) Concentration



Observations from Figures 15-4 through 15-6 include the following:

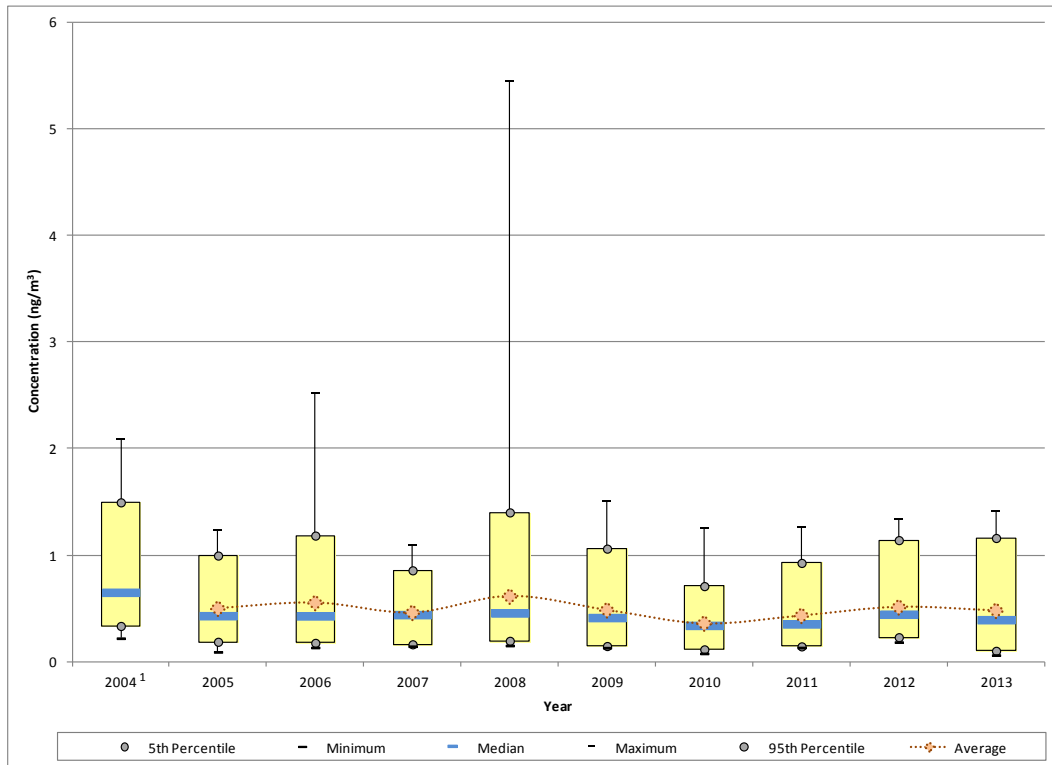
- Figure 15-4 is the box plot for arsenic and shows that BOMA's annual average arsenic (PM₁₀) concentration is less than the program-level average concentration but similar to the program-level median concentration. The maximum concentration measured at BOMA is considerably less than the maximum concentration measured at the program level. There were no non-detects of arsenic measured at BOMA.

- Figure 15-5 is the box plot for naphthalene and shows that the annual average naphthalene concentration for BOMA is less than the program-level average and similar to the program-level median concentration. The maximum concentration measured at BOMA is considerably less than the maximum concentration measured at the program level. There were no non-detects of naphthalene measured at BOMA or across the program.
- Figure 15-6 is the box plot for nickel (PM₁₀). This box plot shows that BOMA's annual average concentration of nickel is greater than the program-level average concentration as well as the program-level third quartile. The minimum nickel concentration measured at BOMA is greater than the program-level first quartile. Although the maximum nickel concentration measured at BOMA is about one-fourth the magnitude of the maximum nickel concentration measured across the program, it is among the higher measurements (ranking 10th highest).

15.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. BOMA has sampled PM₁₀ metals under the NMP since 2003 and PAHs since 2008. Thus, Figures 15-7 through 15-9 present the 1-year statistical metrics for each of the pollutants of interest for BOMA. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 15-7. Yearly Statistical Metrics for Arsenic (PM₁₀) Concentrations Measured at BOMA



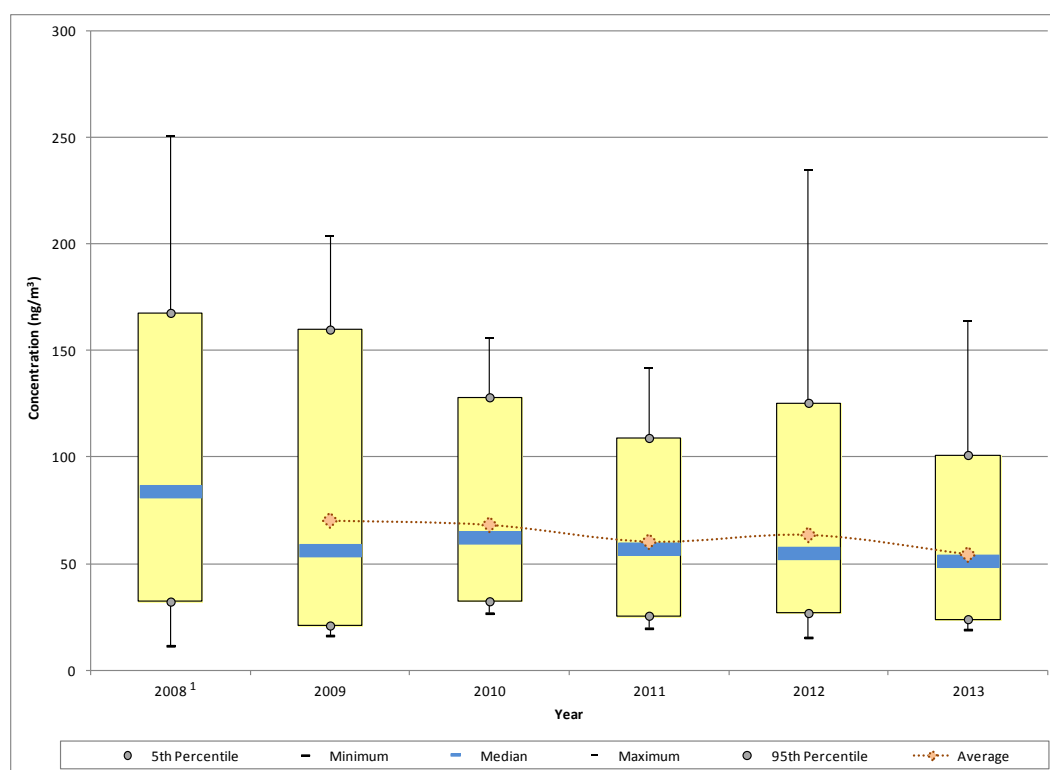
¹ A 1-year average is not presented because there were breaks in sampling during portions of 2004.

Observations from Figure 15-7 for arsenic measurements collected at BOMA include the following:

- Although sampling for PM₁₀ metals under the NMP began in 2003, data from that year were excluded from this analysis because sampling did not begin until October. In addition, samples were not collected during portions of April, May, September, and October 2004. Because a full year's worth of data is not available for 2004, a 1-year average concentration is not presented, although the range of measurements is provided.
- The maximum arsenic concentration shown was measured on July 5, 2008 (5.45 ng/m³). The next highest concentration measured is approximately half as high (2.52 ng/m³) and was measured on July 4, 2006.
- The 1-year average concentrations of arsenic have fluctuated over the years, ranging from 0.36 ng/m³ (2010) to 0.61 ng/m³ (2008). For 2008, the maximum concentration is driving the 1-year average upward, which is evident from the median concentration, which hardly changed between 2007 and 2008, even though the smallest range of measurements was collected in 2007. If the maximum concentration for 2008 was removed from the dataset, the 1-year average concentration for 2008 would fall from 0.61 ng/m³ to 0.53 ng/m³, making the changes in the 1-year averages between 2007 and 2009 more subtle.

- All of the statistical metrics exhibit a decrease from 2008 to 2009 and again for 2010. Conversely, all of the statistical metrics exhibit an increase from 2010 to 2011 and again for 2012.
- For 2013, a higher number of concentrations at the lower end of the concentration range were measured while concentrations at the top of the range changed little. The number of arsenic concentrations less than 0.2 ng/m³ increased from one in 2012 to 13 for 2013. This explains the considerable decrease in the minimum, 5th percentile, and median concentration shown for 2013, as well as the slight decrease in the 1-year average concentration, although the change is not statistically significant.

Figure 15-8. Yearly Statistical Metrics for Naphthalene Concentrations Measured at BOMA



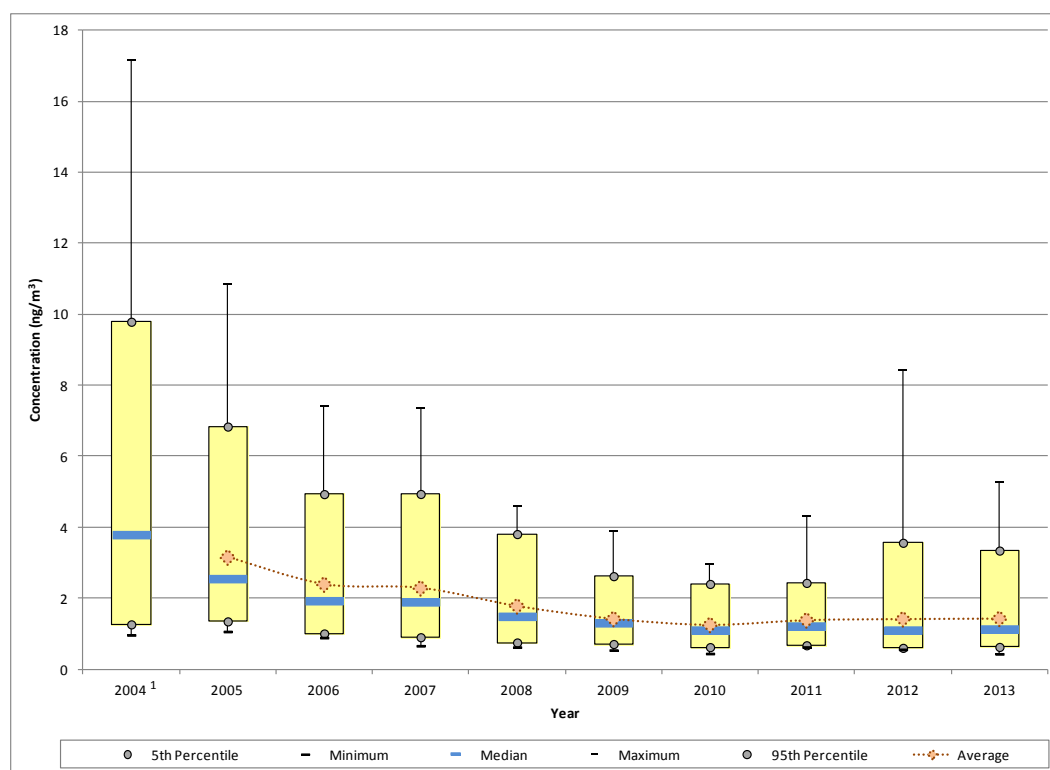
¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2008.

Observations from Figure 15-8 for naphthalene measurements collected at BOMA include the following:

- BOMA began sampling PAHs under the NMP in May 2008. Because a full year's worth of data is not available for 2008, a 1-year average concentration is not presented, although the range of measurements is provided.
- The maximum naphthalene concentration was measured on the very first sample day (May 6, 2008), although a similar measurement was also collected in 2012. Only two additional concentrations greater than 200 ng/m³ have been measured at BOMA (one each in 2008 and 2009).

- The difference between the 5th and 95th percentiles (the range of concentrations within which 90 percent of the measurements lie) decreased each year through 2011. The range increased somewhat for 2012, and is more similar to the range shown for 2010, before decreasing further for 2013.
- The median concentration decreased significantly from 2008 to 2009, from 84.00 ng/m³ to 56.30 ng/m³. Little change is shown after 2008, with the median varying by only 11 ng/m³ between 2009 and 2013. Similarly, the 1-year average concentration varies by only 16 ng/m³ for the years shown, ranging from 54.32 ng/m³ for 2013 to 70.33 ng/m³ for 2009. Both statistical parameters are at a minimum for 2013.

Figure 15-9. Yearly Statistical Metrics for Nickel (PM₁₀) Concentrations Measured at BOMA



¹ A 1-year average is not presented because there were breaks in sampling during portions of 2004.

Observations from Figure 15-9 for nickel measurements collected at BOMA include the following:

- The maximum concentration was measured at BOMA in 2004 (17.2 ng/m³). All but one of the 12 highest nickel concentrations (those greater than 7.50 ng/m³) were measured in 2004 or 2005 (with the other measured in 2012).
- A steady decreasing trend in the nickel measurements collected at BOMA is shown through 2010. Concentrations for 2011 increased just slightly, returning to 2009 levels. Even with the higher concentrations measured in 2012 and 2013, the 1-year

average concentration did not change significantly from 2011 (ranging from 1.38 ng/m³ for 2011 to 1.42 ng/m³ for 2013).

15.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the BOMA monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

15.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for BOMA and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 15-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 15-6. Risk Approximations for the Massachusetts Monitoring Site

Pollutant	Cancer URE (µg/m ³) ⁻¹	Noncancer RfC (mg/m ³)	# of Measured Detections vs. # of Samples	Annual Average (ng/m ³)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Boston, Massachusetts - BOMA						
Arsenic (PM ₁₀)	0.0043	0.000015	61/61	0.48 ± 0.08	2.06	0.03
Naphthalene	0.000034	0.003	61/61	54.32 ± 7.09	1.85	0.02
Nickel (PM ₁₀)	0.00048	0.00009	61/61	1.42 ± 0.23	0.68	0.02

Observations for BOMA from Table 15-6 include the following:

- Among the pollutants of interest for BOMA, naphthalene has the highest annual average concentration while arsenic has the lowest annual average concentration.

- Although the annual average concentration for naphthalene is two orders of magnitude greater than the annual average concentration of arsenic, the cancer risk approximations for these two pollutants are fairly similar (2.06 in-a-million for arsenic and 1.85 in-a-million for naphthalene). This speaks to the relative toxicity of one pollutant compared to the other.
- None of the pollutants of interest for BOMA have noncancer hazard approximations greater than 1.0; in fact, none of the pollutants of interest have noncancer hazard approximations greater than 0.05. This indicates that no adverse noncancer health effects are expected due to these individual pollutants.

15.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 15-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 15-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 15-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for BOMA, as presented in Table 15-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 15-7. Table 15-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 15.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 15-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Massachusetts Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Boston, Massachusetts (Suffolk County) - BOMA					
Formaldehyde	143.05	Formaldehyde	1.86E-03	Arsenic	2.06
Benzene	137.55	Nickel, PM	1.22E-03	Naphthalene	1.85
Acetaldehyde	66.22	Benzene	1.07E-03	Nickel	0.68
Ethylbenzene	64.30	1,3-Butadiene	7.34E-04		
1,3-Butadiene	24.47	Arsenic, PM	4.62E-04		
Tetrachloroethylene	19.26	Hexavalent Chromium	4.41E-04		
Naphthalene	10.82	Naphthalene	3.68E-04		
POM, Group 2b	3.41	POM, Group 2b	3.00E-04		
Nickel, PM	2.53	Ethylbenzene	1.61E-04		
POM, Group 2d	1.66	POM, Group 2d	1.46E-04		

Table 15-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Massachusetts Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Boston, Massachusetts (Suffolk County) - BOMA					
Toluene	511.53	Acrolein	501,247.48	Arsenic	0.03
Hexane	399.62	Nickel, PM	28,149.17	Naphthalene	0.02
Xylenes	271.73	Formaldehyde	14,596.91	Nickel	0.02
Formaldehyde	143.05	1,3-Butadiene	12,234.00		
Benzene	137.55	Acetaldehyde	7,357.30		
Acetaldehyde	66.22	Arsenic, PM	7,162.73		
Ethylbenzene	64.30	Benzene	4,584.90		
Methyl isobutyl ketone	55.81	Naphthalene	3,605.47		
1,3-Butadiene	24.47	Cadmium, PM	3,035.10		
Tetrachloroethylene	19.26	Xylenes	2,717.32		

Observations from Table 15-7 include the following:

- Formaldehyde, benzene, and acetaldehyde are the highest emitted pollutants with cancer UREs in Suffolk County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, nickel, and benzene.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions.
- All three of BOMA's pollutants of interest appear among the pollutants with the highest toxicity-weighted emissions for Suffolk County. Nickel and naphthalene are also among those with the highest total emissions in Suffolk County while arsenic is not among the highest emitted (it ranks 16th).
- POM, Group 2b ranks eighth for both quantity emitted and its toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at BOMA including acenaphthene and fluorene, both of which failed a single screen but were not identified as pollutants of interest. POM, Group 2d ranks tenth for both quantity emitted and its toxicity-weighted emissions. POM, Group 2d includes several PAHs sampled for at BOMA, including anthracene and phenanthrene, although none of these failed screens for BOMA.

Observations from Table 15-8 include the following:

- Toluene, hexane, and xylenes are the highest emitted pollutants with noncancer RfCs in Suffolk County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, nickel, and formaldehyde.
- Five of the highest emitted pollutants also have the highest toxicity-weighted emissions.
- All three of BOMA's pollutants of interest appear among the pollutants with the highest toxicity-weighted emissions for Suffolk County, although none of these appear among the highest emitted pollutants. Cadmium, which was also sampled for at BOMA but did not fail any screens, also appears among the pollutants with the highest toxicity-weighted emissions for Suffolk County

15.6 Summary of the 2013 Monitoring Data for BOMA

Results from several of the data treatments described in this section include the following:

- ❖ *Seven pollutants failed screens for BOMA, with naphthalene and arsenic accounting for a majority of the failed screens.*

- ❖ *Naphthalene had the highest annual average concentration among the pollutants of interest for BOMA.*
- ❖ *Even though concentrations of nickel have a decreasing trend over most of the years of sampling, BOMA has the fifth highest annual average concentration of nickel for 2013 among NMP sites sampling PM₁₀ metals.*

16.0 Site in Michigan

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Michigan, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

16.1 Site Characterization

This section characterizes the monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The DEMI monitoring site is located in the Detroit-Warren-Dearborn, Michigan CBSA. Figure 16-1 is the composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 16-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 16-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize the emissions sources within the boundary. Table 16-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 16-1. Dearborn, Michigan (DEMI) Monitoring Site

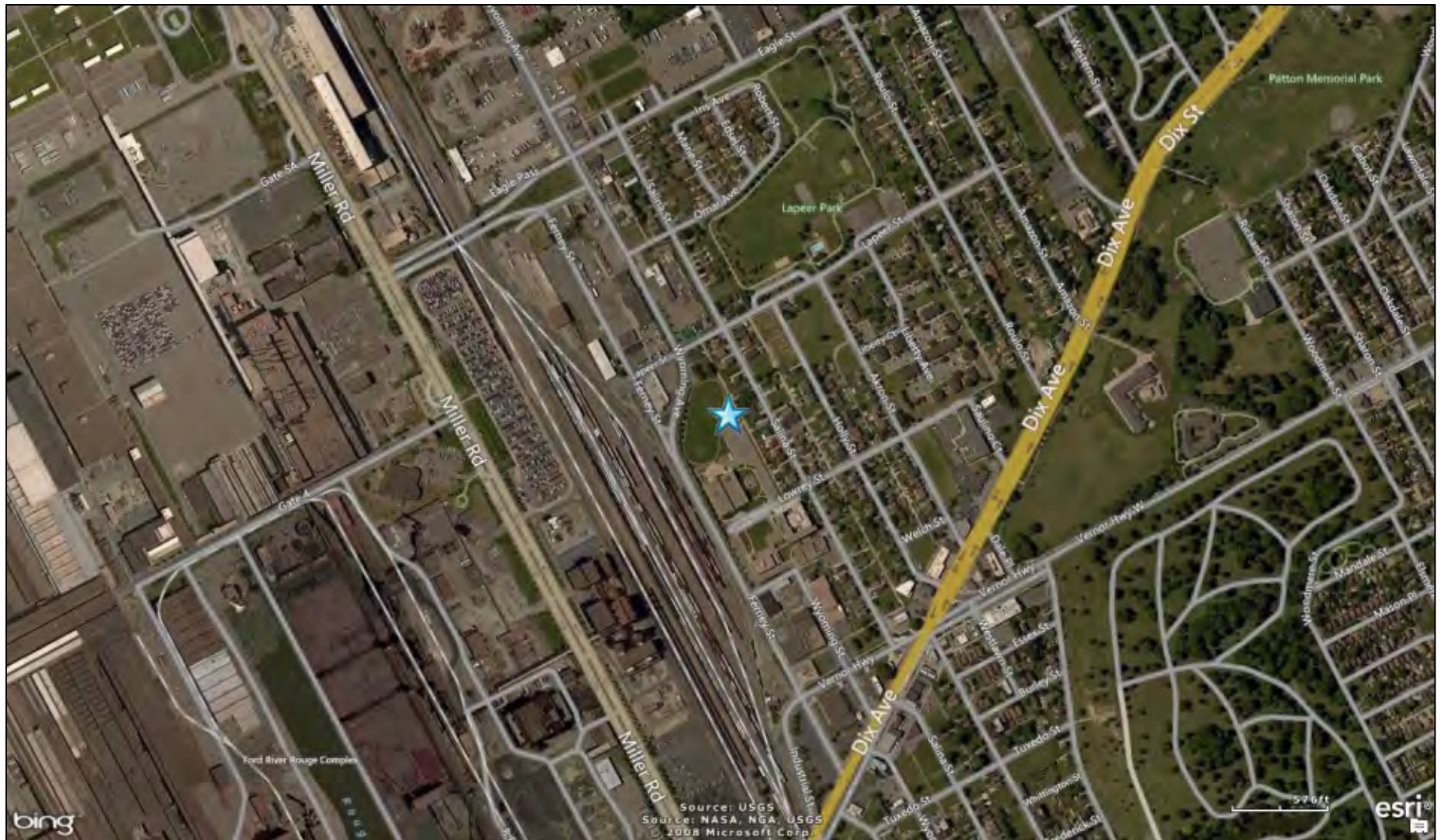


Figure 16-2. NEI Point Sources Located Within 10 Miles of DEMI

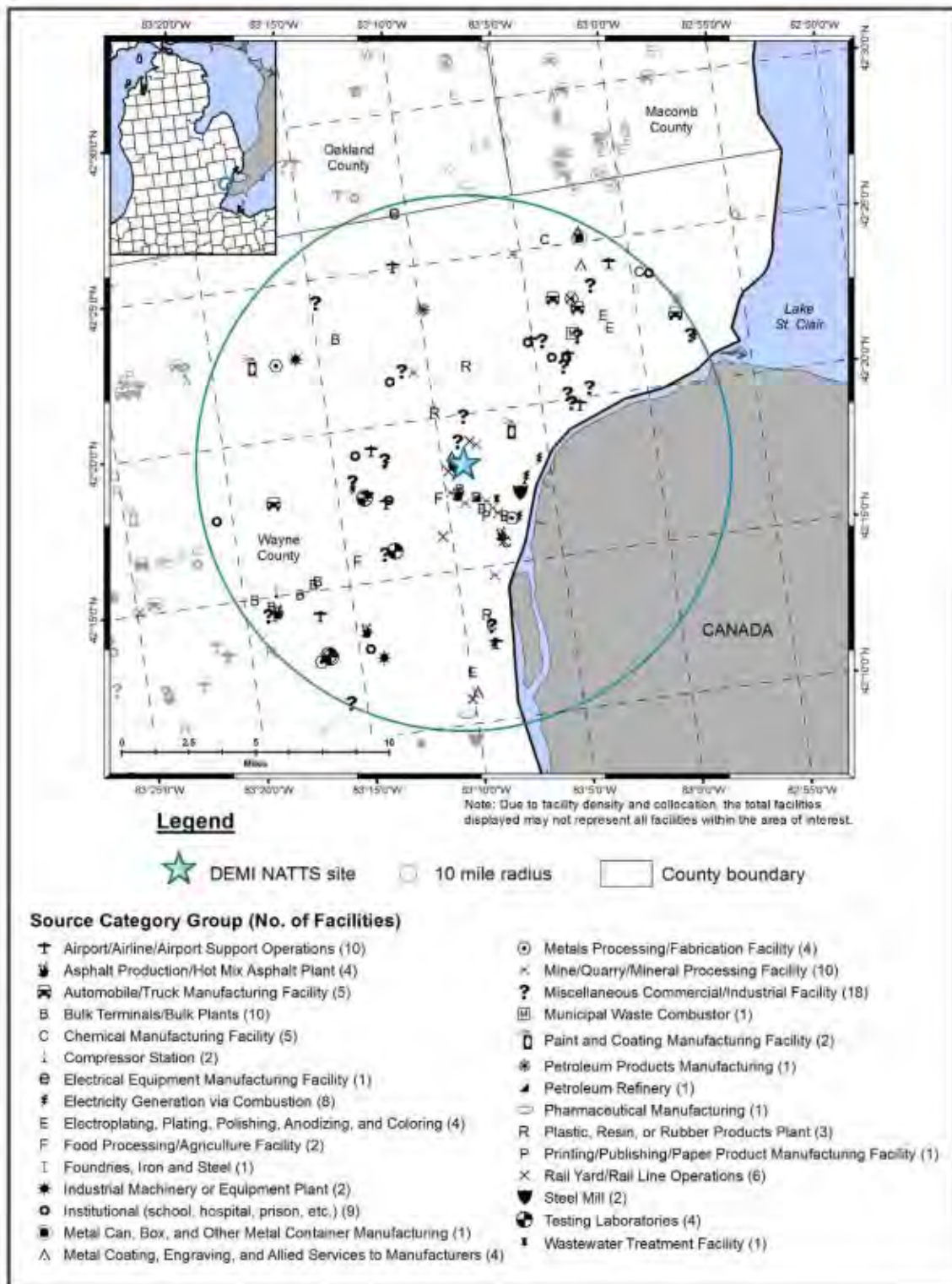


Table 16-1. Geographical Information for the Michigan Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>DEMI</i>	26-163-0033	Dearborn	Wayne	Detroit-Warren-Dearborn, MI	42.306666, -83.148889	Industrial	Suburban	TSP Metals, Meteorological parameters, PM ₁₀ , PM ₁₀ Speciation, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation, Black carbon.

¹Data for additional pollutants are reported to AQS for this site (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

DEMI is located in the parking lot of Salina Elementary School in Dearborn, just southwest of Detroit, and is the Detroit NATTS site. The surrounding area is both suburban and industrial in nature. Figure 16-1 shows that a freight yard is located just west of the site and a residential neighborhood is located to the east. Industrial sources such as automobile and steel manufacturing facilities are also located in the vicinity. The monitoring site lies between two heavily traveled roadways, I-75 (1.4 miles to the east) and I-94 (1.2 miles to the west).

Figure 16-2 shows that DEMI is surrounded by numerous point sources. A cluster of sources is located just west of DEMI. Another cluster of sources is located farther south. The source categories with the most point sources within 10 miles of the site include the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; bulk terminals and bulk plants; mines, quarries, and mineral processing facilities; and institutional facilities (schools, prisons, and/or hospitals). Although difficult to discern in Figure 16-2, the closest sources to DEMI are just west of the site and include a steel mill, an automobile/truck manufacturing facility, a facility generating electricity via combustion, a metal coatings facility, and a rail yard. Note that DEMI is located approximately 3 miles from the Canadian border, and that no emission sources information is provided for Canada.

Table 16-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Michigan monitoring site. Table 16-2 includes both county-level population and vehicle registration information. Table 16-2 also contains traffic volume information for DEMI as well as the location for which the traffic volume was obtained. Additionally, Table 16-2 presents the county-level daily VMT for Wayne County.

Table 16-2. Population, Motor Vehicle, and Traffic Information for the Michigan Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
DEMI	Wayne	1,775,273	1,335,516	94,600	I-94 from Ford Plant to Rotunda Dr	41,554,962

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2013 data (MDS, 2014)

³AADT reflects 2013 data (MI DOT, 2013)

⁴County-level VMT reflects 2013 data (MI DOT, 2014)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 16-2 include the following:

- Wayne County's population and vehicle registration both rank eighth highest among counties with NMP sites.
- The traffic volume near DEMI ranks 16th among NMP sites. Traffic for DEMI is provided for I-94, between the Ford Plant and Rotunda Drive.
- The Wayne County daily VMT is the sixth highest VMT compared to other counties with NMP sites.

16.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Michigan on sample days, as well as over the course of the year.

16.2.1 Climate Summary

Detroit is located in southeast Michigan, where the Detroit River serves as the U.S./Canadian border, and is situated directly across from Windsor, Canada's southernmost city. The river separates the two cities and is a channel between Lake St. Clair to the east and Lake Erie to the south. Detroit is located in a region of active weather. Winters tend to be cold and wet, with snowfall amounts around 35 inches per year. Summers are generally mild, although temperatures exceeding 90°F are common. Precipitation is fairly well distributed throughout the year, with summer precipitation coming primarily in the form of showers and thunderstorms. The urbanization of the area and Lake St. Clair are major influences on the city's weather. The lake tends to keep the Detroit area warmer in the winter and cooler in the summer than more inland areas. The urban heat island also keeps the city warmer than outlying areas. Winds are often breezy and flow from the southwest on average (Wood, 2004; MSU, 2015a and 2015b).

16.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Michigan monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station to DEMI is located at Detroit City Airport (WBAN 14822). Additional information about this weather station, such as the distance between the site and the weather station, is provided in Table 16-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 16-3. Average Meteorological Conditions near the Michigan Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Dearborn, Michigan - DEMI									
Detroit City Airport 14822 (42.41, -83.01)	10.0 miles	Sample Day (68)	55.9 ± 5.3	48.9 ± 4.9	38.3 ± 4.9	44.0 ± 4.5	69.0 ± 3.1	1017.5 ± 1.7	7.2 ± 0.7
	45° (NE)	2013	57.4 ± 2.1	50.0 ± 2.0	39.3 ± 1.9	45.0 ± 1.8	68.8 ± 1.1	1017.3 ± 0.7	6.8 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 16-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 16-3 is the 95 percent confidence interval for each parameter. Average meteorological conditions on sample days near DEMI appear slightly cooler than conditions experienced throughout the year, although the difference is not statistically significant. A number of make-up samples were collected at DEMI throughout the year, most of which were collected during cooler parts of the year (one each in March, April, September, October, and November, and two in December).

16.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at the Detroit City Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

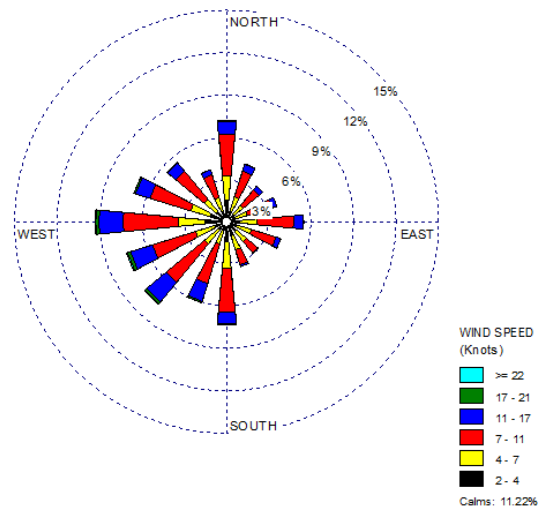
Figure 16-3 presents a map showing the distance between the weather station and DEMI, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 16-3 also presents three different wind roses for the DEMI monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 16-3. Wind Roses for the Detroit City Airport Weather Station near DEMI

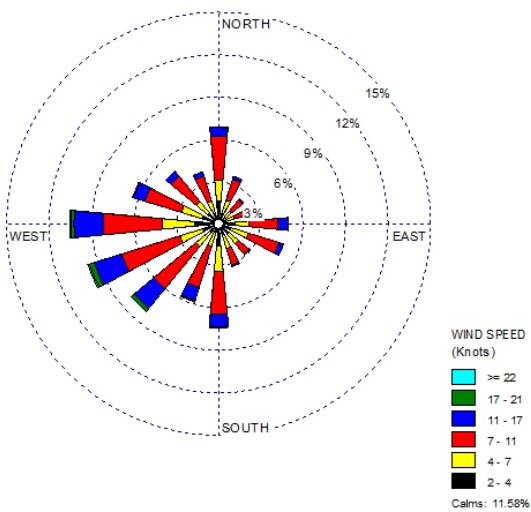
Location of DEMI and Weather Station



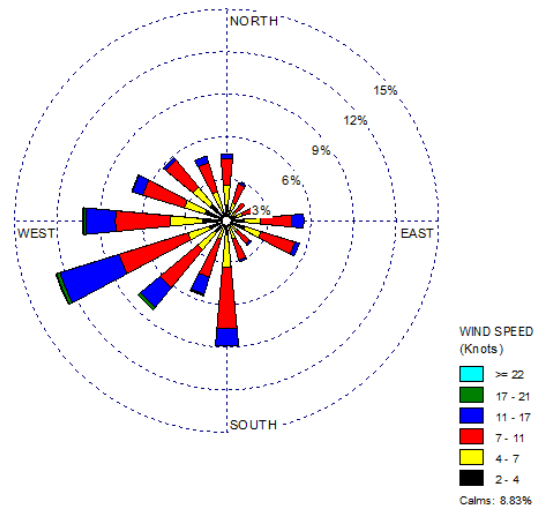
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 16-3 include the following:

- The weather station at Detroit City Airport is located 10 miles to the northeast of DEMI. Most of the city of Detroit lies between the weather station and the monitoring site.
- The historical wind roses show that winds from a variety of directions were observed near DEMI, although winds from the southwest to west were the most frequently observed while winds from the northeast and southeast quadrants were observed the least. Calm winds (those less than or equal to 2 knots) were observed for approximately 11 percent of the hourly measurements.
- The wind patterns on the 2013 wind rose resemble the historical wind patterns, although there was a higher percentage of wind observations from the south-southwest and west.
- The sample day wind rose for DEMI bears some resemblance to the full-year wind rose, although there are also differences. Winds from the west-southwest account for an even greater number of observations on sample days while the number of northerly wind observations was down considerably. The percentage of calm winds is lower on the sample day wind rose, accounting for less than 9 percent of the hourly measurements.

16.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for DEMI in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 16-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 16-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. VOCs, carbonyl compounds, PAHs, and hexavalent chromium were sampled for at DEMI. Note that hexavalent chromium sampling was discontinued at DEMI at the end of June 2013.

Table 16-4. Risk-Based Screening Results for the Michigan Monitoring Site

Pollutant	Screening Value ($\mu\text{g}/\text{m}^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Dearborn, Michigan - DEMI						
Benzene	0.13	62	62	100.00	12.58	12.58
Carbon Tetrachloride	0.17	62	62	100.00	12.58	25.15
Acetaldehyde	0.45	61	61	100.00	12.37	37.53
Formaldehyde	0.077	61	61	100.00	12.37	49.90
Naphthalene	0.029	60	60	100.00	12.17	62.07
1,3-Butadiene	0.03	58	58	100.00	11.76	73.83
1,2-Dichloroethane	0.038	57	57	100.00	11.56	85.40
Ethylbenzene	0.4	19	62	30.65	3.85	89.25
Acenaphthene	0.011	18	60	30.00	3.65	92.90
Fluorene	0.011	17	59	28.81	3.45	96.35
Fluoranthene	0.011	6	60	10.00	1.22	97.57
Hexavalent Chromium	0.000083	4	22	18.18	0.81	98.38
Hexachloro-1,3-butadiene	0.045	3	3	100.00	0.61	98.99
Dichloromethane	60	1	62	1.61	0.20	99.19
Propionaldehyde	0.8	1	61	1.64	0.20	99.39
Styrene	100	1	62	1.61	0.20	99.59
Tetrachloroethylene	3.8	1	62	1.61	0.20	99.80
Trichloroethylene	0.2	1	8	12.50	0.20	100.00
Total		493	942	52.34		

Observations from Table 16-4 for DEMI include the following:

- Eighteen pollutants failed at least one screen for DEMI; greater than 50 percent of concentrations for these 18 pollutants were greater than their associated risk screening value (or failed screens).
- Ten pollutants contributed to 95 percent of failed screens for DEMI and therefore were identified as pollutants of interest for DEMI. These 10 include two carbonyl compounds, five VOCs, and three PAHs.
- The first seven pollutants listed in Table 16-4 each failed 100 percent of screens, with each contributing to roughly 12 percent to the total number of failed screens; together these seven pollutants account for more than 85 percent of the total failed screens.
- Four VOCs listed in Table 16-4 failed a single screen. The concentrations of each of these pollutants that failed the screen were measured on the same day, October 15, 2013. The highest concentrations of 1,3-butadiene and 1,2-dichloroethane were also measured on this day at DEMI.

16.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Michigan monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each data analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at DEMI are provided in Appendices J, L, M, and O.

16.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Michigan site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Michigan monitoring site are presented in Table 16-5, where applicable. Note that concentrations of the PAHs are presented in ng/m³ for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 16-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Michigan Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Dearborn, Michigan - DEMI						
Acetaldehyde	61/61	1.77 ± 0.26	2.01 ± 0.22	1.85 ± 0.25	1.43 ± 0.21	1.76 ± 0.12
Benzene	62/62	0.83 ± 0.11	0.58 ± 0.09	0.65 ± 0.14	0.55 ± 0.11	0.65 ± 0.06
1,3-Butadiene	58/62	0.09 ± 0.03	0.06 ± 0.02	0.08 ± 0.02	0.08 ± 0.03	0.08 ± 0.01
Carbon Tetrachloride	62/62	0.65 ± 0.05	0.72 ± 0.06	0.68 ± 0.04	0.64 ± 0.02	0.67 ± 0.02
1,2-Dichloroethane	57/62	0.08 ± 0.01	0.09 ± 0.01	0.06 ± 0.02	0.07 ± 0.02	0.08 ± 0.01
Ethylbenzene	62/62	0.31 ± 0.11	0.26 ± 0.06	0.68 ± 0.36	0.31 ± 0.13	0.39 ± 0.10
Formaldehyde	61/61	2.38 ± 0.32	3.44 ± 0.57	4.22 ± 0.75	2.20 ± 0.22	3.05 ± 0.31
Acenaphthene ^a	60/60	2.83 ± 0.97	14.38 ± 6.76	17.47 ± 5.90	3.80 ± 1.67	9.62 ± 2.72
Fluorene ^a	59/60	2.95 ± 0.91	12.36 ± 5.05	14.49 ± 4.75	3.58 ± 1.17	8.35 ± 2.13
Naphthalene ^a	60/60	99.17 ± 39.51	114.16 ± 24.02	137.51 ± 27.64	67.45 ± 14.28	104.57 ± 14.63

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for DEMI from Table 16-5 include the following:

- The pollutants with the highest annual average concentrations are formaldehyde and acetaldehyde; all other annual average concentrations are less than $1.0 \mu\text{g}/\text{m}^3$.
- The second and third quarter average concentrations of formaldehyde are greater than the other quarterly averages, supporting the seasonal trend identified in Section 4.4.2. A review of the data shows that concentrations of formaldehyde measured at DEMI range from $1.42 \mu\text{g}/\text{m}^3$ to $7.22 \mu\text{g}/\text{m}^3$, with the three highest concentrations of formaldehyde measured in August 2013. The 15 highest concentrations measured at DEMI (those greater than $3.5 \mu\text{g}/\text{m}^3$) were measured between May and September. Conversely, all but two of the 13 formaldehyde concentrations less than $2 \mu\text{g}/\text{m}^3$ were measured during the first or fourth quarters of 2013. Concentrations of acetaldehyde measured at DEMI do not exhibit the same seasonal tendency as formaldehyde.
- The third quarter average concentration of ethylbenzene is roughly twice the other quarterly averages and has a relatively large confidence interval associated with it. A review of the data shows that the maximum concentration of this pollutant was measured on August 2, 2013 ($2.32 \mu\text{g}/\text{m}^3$), with the second highest concentration measured on the previous sample day ($1.88 \mu\text{g}/\text{m}^3$, measured on July 27, 2013). All other concentrations measured were less than $1 \mu\text{g}/\text{m}^3$. The maximum ethylbenzene

concentration measured at DEMI is also the highest ethylbenzene concentration measured among NMP sites sampling this pollutant. Only five NMP sites measured concentrations of ethylbenzene greater than 2 $\mu\text{g}/\text{m}^3$.

- Of the PAHs, naphthalene has the highest annual average concentration for DEMI. Naphthalene concentrations appear to be highest during the warmer months, based on the quarterly average concentrations of naphthalene, although all four have relatively large confidence intervals associated with them, indicating that the measurements are highly variable. Note, however, the confidence interval is highest for the first quarter average. The maximum concentration of naphthalene (314 ng/m^3) was measured on January 10, 2013, with the other three concentrations greater than 200 ng/m^3 measured during the second and third quarters of 2013. At least one concentration greater than 100 ng/m^3 was measured during each quarter of 2013: four during the first quarter, nine during the second, 11 during the third, and two during the fourth.
- The second and third quarter average concentrations of acenaphthene and fluorene are significantly higher than the other quarterly averages and have relatively large confidence intervals associated with them. The maximum concentrations of these two pollutants were measured on the same day, June 9, 2013. The highest concentrations of these pollutants were measured in June, July, and August, generally on the same days, although the order varied. A similar observation was made in the 2011 and 2012 NMP reports.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for DEMI from those tables include the following:

- DEMI appears in Table 4-9 for VOCs only once, having the sixth highest annual average concentration of carbon tetrachloride. However, with the exception of two sites (BLKY and TVKY), and the difference among the annual average concentrations of this pollutant varies little.
- DEMI does not appear in Table 4-10 among the NMP sites with the highest annual average concentrations of acetaldehyde and formaldehyde.
- The annual average concentration of acenaphthene for DEMI is the third highest among NMP sites sampling PAHs, as shown in Table 4-11. DEMI's annual average concentration of naphthalene ranks fifth among NMP sites sampling PAHs.

16.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in

gray in Table 16-4. Figures 16-4 through 16-13 overlay the Michigan site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 16-4. Program vs. Site-Specific Average Acenaphthene Concentration

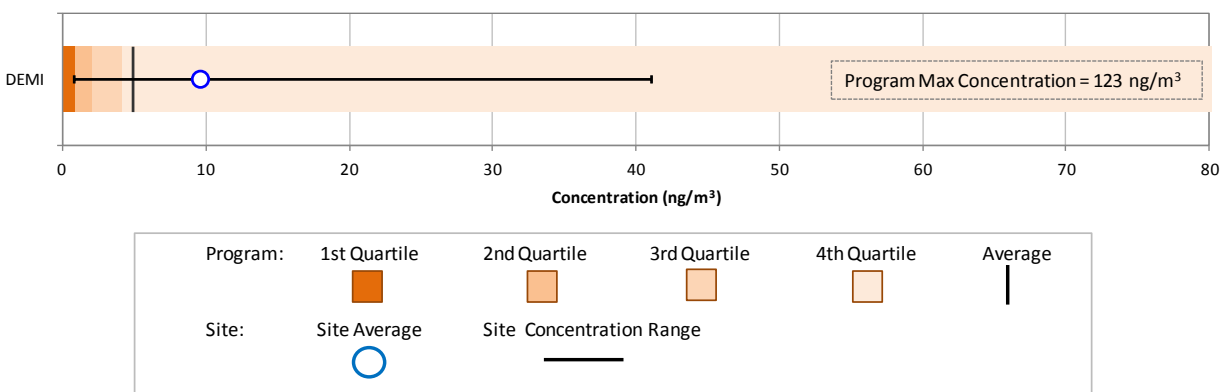


Figure 16-5. Program vs. Site-Specific Average Acetaldehyde Concentration

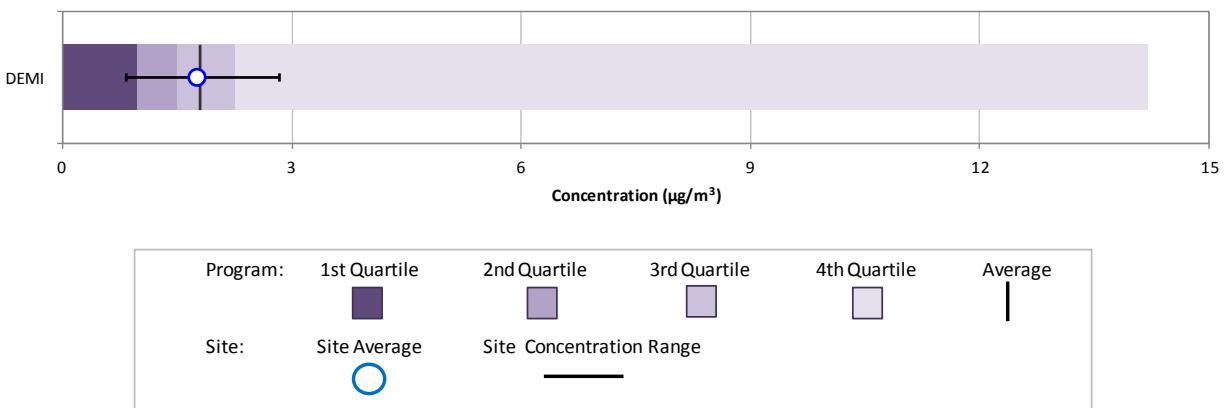


Figure 16-6. Program vs. Site-Specific Average Benzene Concentration

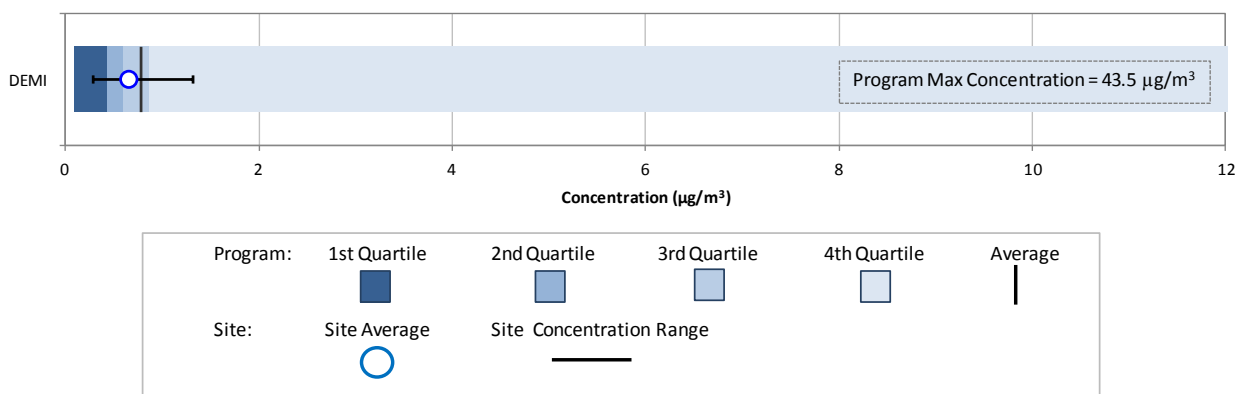


Figure 16-7. Program vs. Site-Specific Average 1,3-Butadiene Concentration

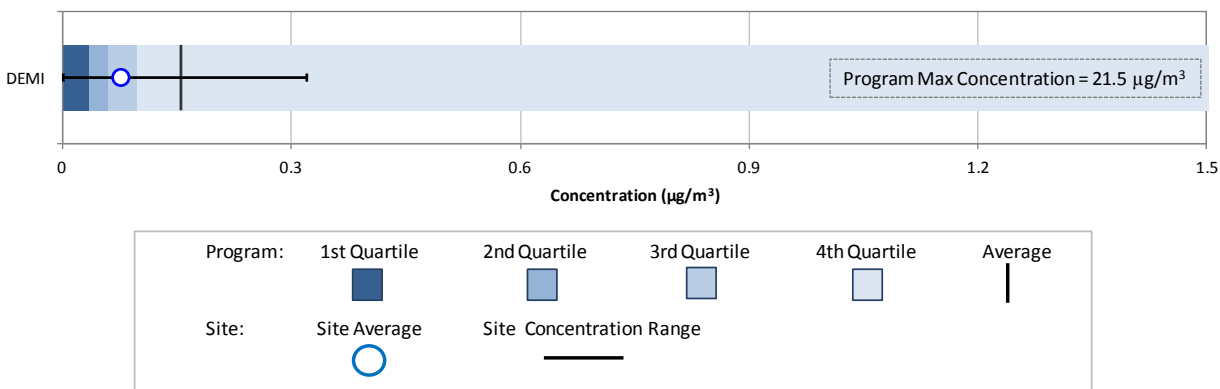


Figure 16-8. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

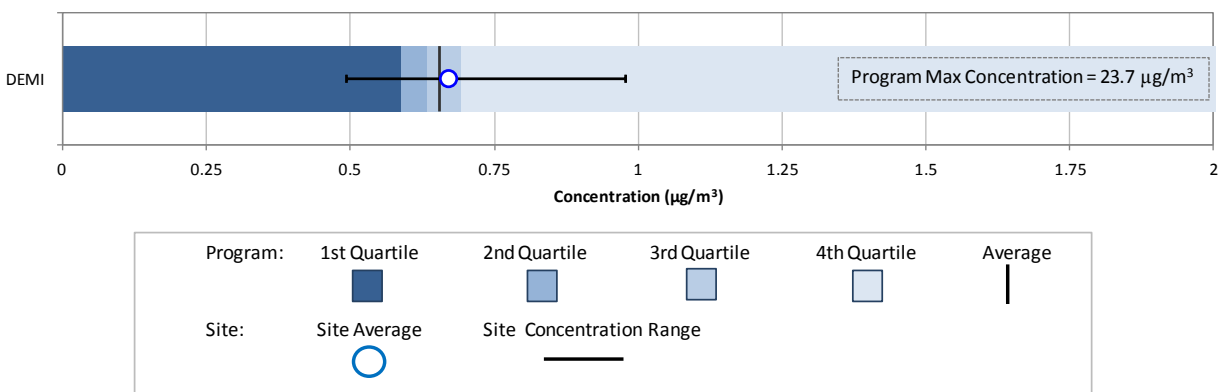


Figure 16-9. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

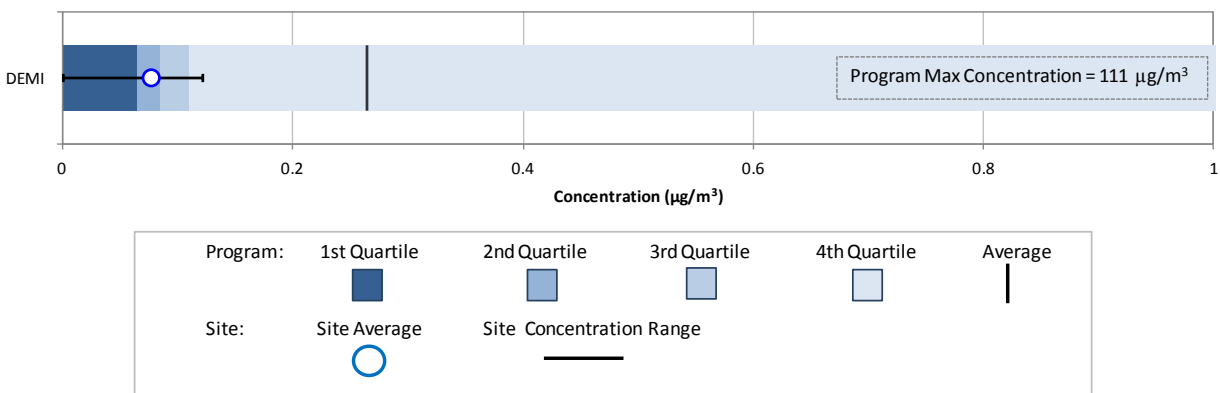


Figure 16-10. Program vs. Site-Specific Average Ethylbenzene Concentration

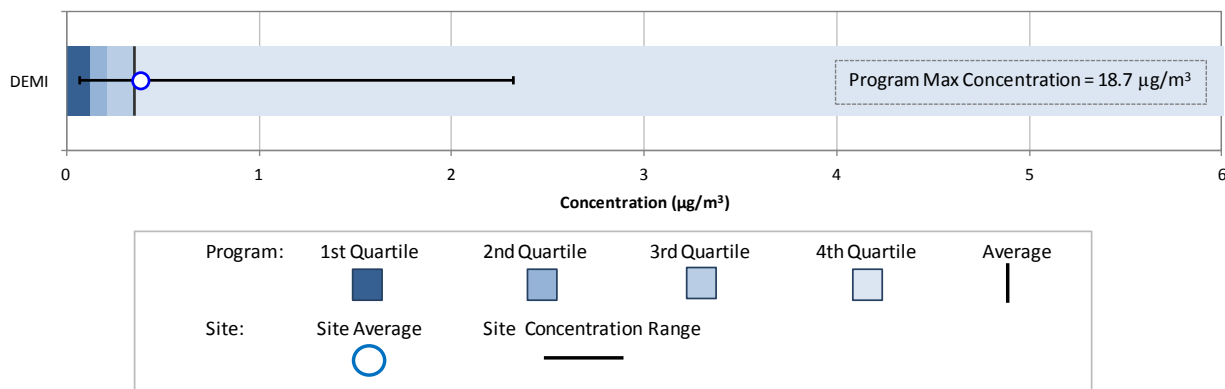


Figure 16-11. Program vs. Site-Specific Average Fluorene Concentration

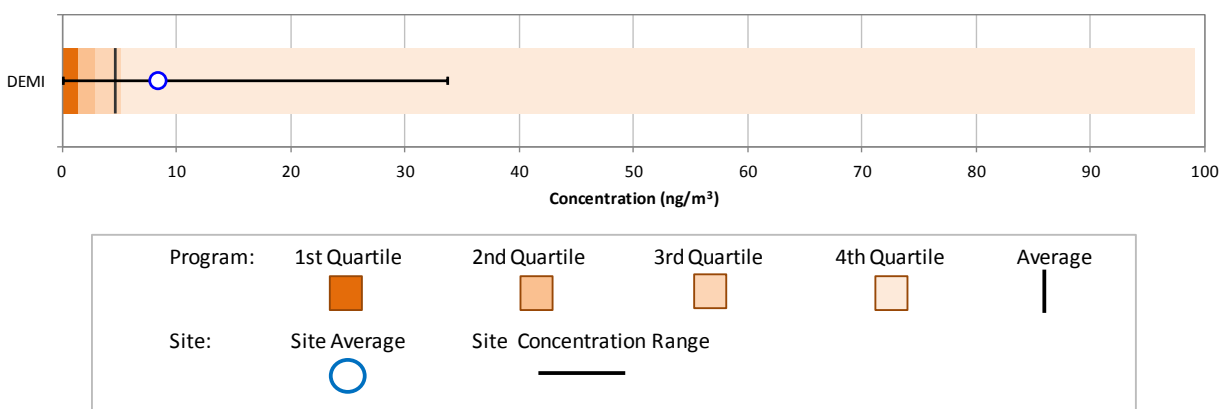


Figure 16-12. Program vs. Site-Specific Average Formaldehyde Concentration

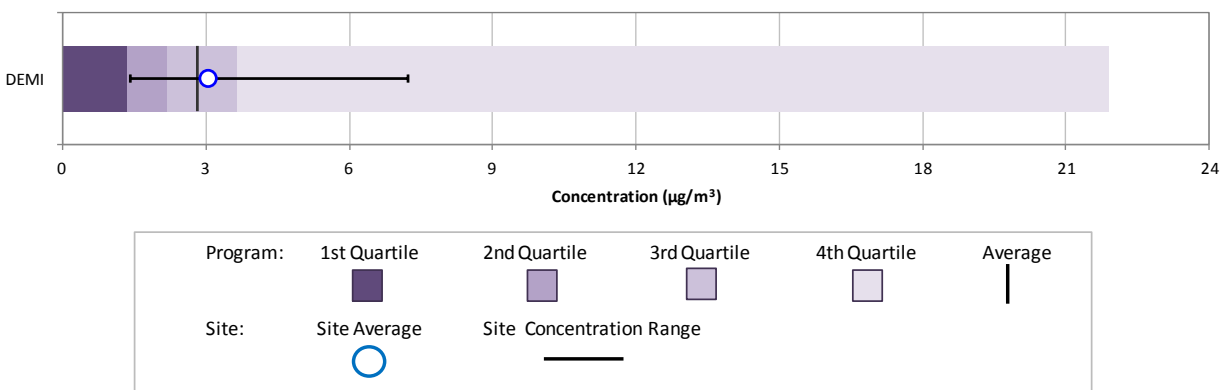
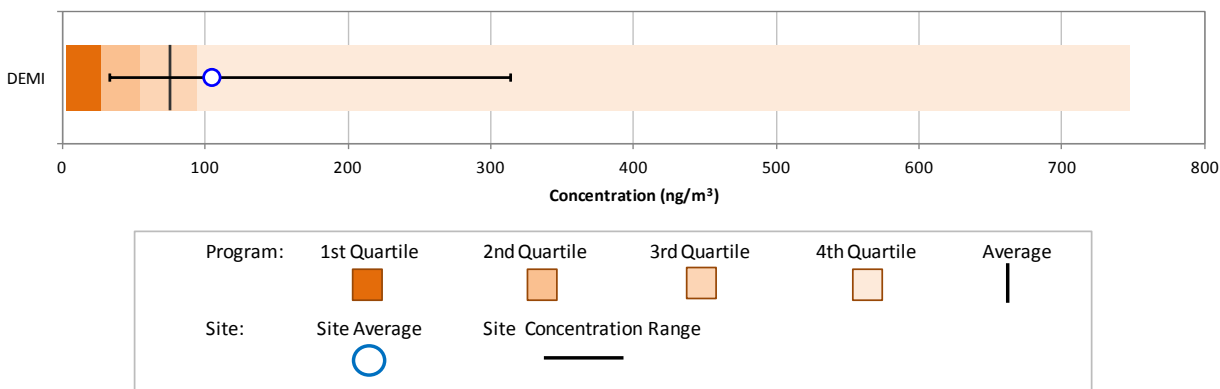


Figure 16-13. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 16-4 through 16-13 include the following:

- Figure 16-4 is the box plot for acenaphthene for DEMI. Note that the program-level maximum concentration (123 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 80 ng/m^3 . This box plot shows that the maximum acenaphthene concentration measured at DEMI is considerably less than the maximum concentration across the program. The annual average acenaphthene concentration for DEMI ($9.62 \pm 2.72 \text{ ng/m}^3$) is nearly twice the program-level average concentration (4.88 ng/m^3). There were no non-detects of acenaphthene measured at DEMI.
- Figure 16-5 is the box plot for acetaldehyde. The box plot shows that the maximum acetaldehyde concentration measured at DEMI is significantly less than the program-level maximum concentration while the minimum concentration measured at DEMI is just less than the first quartile for the program. The annual average concentration of acetaldehyde for DEMI is similar to the program-level average concentration.
- Figure 16-6 is the box plot for benzene. Similar to acenaphthene, the program-level maximum benzene concentration ($43.5 \text{ } \mu\text{g/m}^3$) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to $12 \text{ } \mu\text{g/m}^3$. This box plot shows that the range of benzene concentrations measured at DEMI spans just over $1 \text{ } \mu\text{g/m}^3$. DEMI's annual average benzene concentration ($0.65 \pm 0.06 \text{ } \mu\text{g/m}^3$) is less than the program-level average concentration ($0.78 \text{ } \mu\text{g/m}^3$) but greater than the program-level median concentration ($0.60 \text{ } \mu\text{g/m}^3$).
- Figure 16-7 is the box plot for 1,3-butadiene. The program-level maximum concentration ($21.5 \text{ } \mu\text{g/m}^3$) is not shown directly on the box plot as the scale has been reduced to $1.5 \text{ } \mu\text{g/m}^3$ to allow for the observation of data points at the lower end of the concentration range. Figure 16-7 shows that the range of 1,3-butadiene concentrations measured at DEMI is relatively small compared to the range measured across the program. However, the concentrations at the upper end of the

concentration range are driving the program-level average, as more than 75 percent of the 1,3-butadiene measurements are less than $0.1 \mu\text{g}/\text{m}^3$. The annual average concentration for DEMI ($0.08 \pm 0.01 \mu\text{g}/\text{m}^3$) is roughly half the program-level average concentration of this pollutant ($0.15 \mu\text{g}/\text{m}^3$).

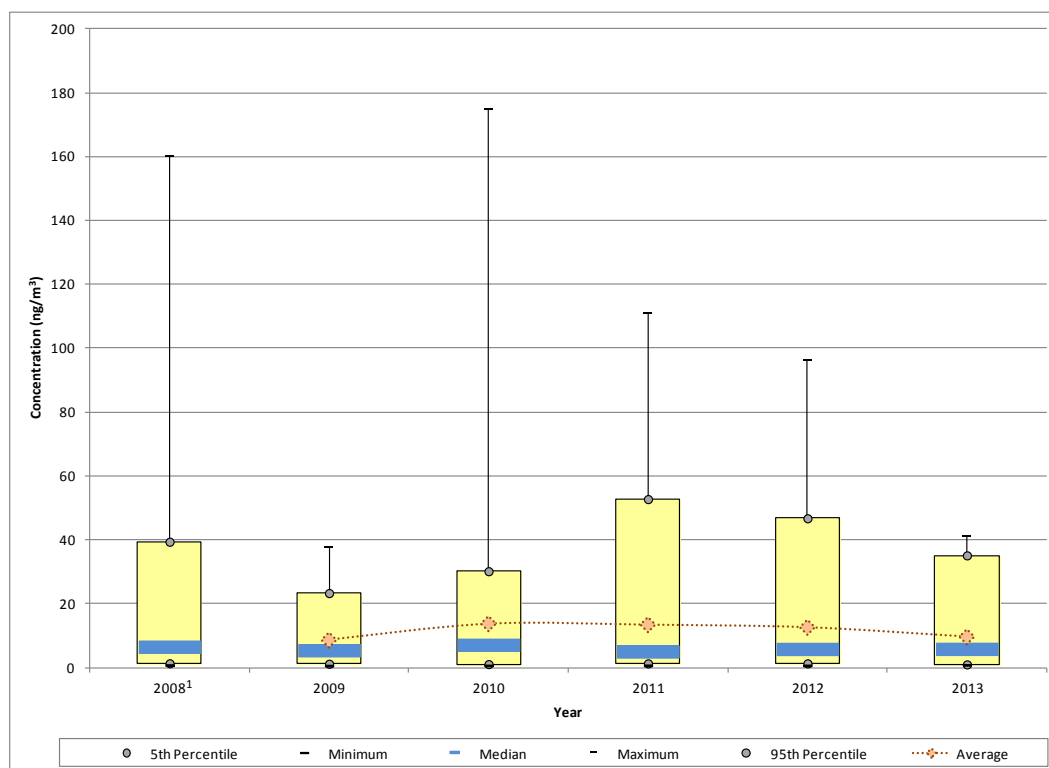
- Figure 16-8 presents the box plot for carbon tetrachloride for DEMI. The scale of the box plot has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum carbon tetrachloride concentration ($23.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Figure 16-8 shows that the range of carbon tetrachloride concentrations measured at DEMI spans approximately $0.5 \mu\text{g}/\text{m}^3$, with a maximum concentration that is considerably less than the program-level maximum concentration. DEMI's annual average concentration of carbon tetrachloride ($0.67 \pm 0.02 \mu\text{g}/\text{m}^3$) falls between the program-level average concentration and third quartile.
- The scale of the box plot in Figure 16-9 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum 1,2-dichloroethane concentration ($111 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. All of the concentrations of 1,2-dichloroethane measured at DEMI are less than the program-level average concentration of $0.26 \mu\text{g}/\text{m}^3$. The annual average concentration for DEMI is just less than the program-level median concentration. This is another example of measurements at the upper end of the concentration range driving the program-level average concentration, as the program-level average is more than twice the program-level third quartile.
- Figure 16-10 is the box plot for ethylbenzene for DEMI. The scale of this box plot has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum ethylbenzene concentration ($18.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Figure 16-10 shows that all of the ethylbenzene concentrations measured at DEMI are less than $3 \mu\text{g}/\text{m}^3$. DEMI's annual average concentration of ethylbenzene is just greater than the program-level average concentration.
- The box plot for fluorene presented in Figure 16-11 shows that the maximum fluorene concentration measured at DEMI is about one-third the maximum concentration of fluorene measured across the program. Yet, the annual average concentration for DEMI is just less than twice the program-level average concentration of this pollutant.
- Figure 16-12 presents the box plot for formaldehyde for DEMI. The maximum formaldehyde concentration measured at DEMI is about one-third the maximum concentration measured across the program while the minimum concentration measured at DEMI is greater than the program-level first quartile. The annual average concentration for DEMI is just greater than the program-level average concentration.

- Figure 16-13 is the box plot for naphthalene. The maximum naphthalene concentration measured at DEMI is considerably less than the maximum concentration measured across the program while the minimum concentration measured at DEMI is greater than the program-level first quartile. The annual average concentration of naphthalene for DEMI is greater than the program-level average concentration and program-level third quartile.

16.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. DEMI has sampled VOCs and carbonyl compounds under the NMP since 2003, and PAHs since 2008. Thus, Figures 16-14 through 16-23 present the 1-year statistical metrics for each of the pollutants of interest for DEMI. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 16-14. Yearly Statistical Metrics for Acenaphthene Concentrations Measured at DEMI

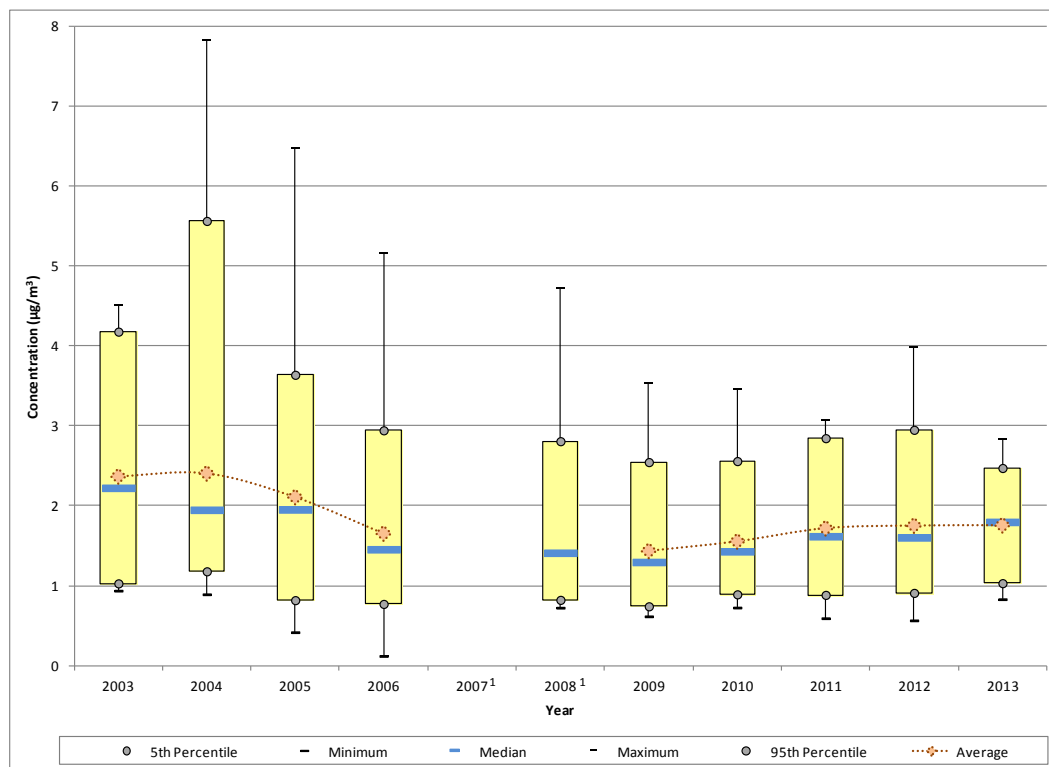


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 16-14 for acenaphthene measurements collected at DEMI include the following:

- DEMI began sampling PAHs under the NMP in April 2008. Because a full year's worth of data is not available for 2008, a 1-year average concentration is not presented, although the range of measurements is provided.
- The maximum acenaphthene concentration measured at DEMI was measured in August 2010 (175 ng/m³). All five concentrations greater than 100 ng/m³ measured at DEMI were measured in either July or August; further, all 46 measurements greater than 20 ng/m³ were measured during the second or third quarters of a given year (during the warmer months of the year).
- The range of concentrations measured decreased from 2008 to 2009 as the maximum concentration for 2009 is less than the 95th percentile for 2008.
- Nearly all of the statistical metrics increased from 2009 to 2010, including the median concentration. The median is influenced less by a few concentrations at the upper end of the concentration range than the 1-year average concentration, such as the two concentrations greater than 100 ng/m³ that were measured in 2010. The third highest concentration measured in 2010 was considerably less (55.1 ng/m³) but still among the higher measurements collected at this site.
- Although the 95th percentile increased considerably from 2010 to 2011, several of the other statistical metrics exhibit decreases (however slight). The number of concentrations greater than 20 ng/m³ increased from five to 12 from 2010 to 2011, accounting for one-fifth of the measurements collected in 2011.
- The range of concentrations measured has a decreasing trend between 2010 and 2013, with the lowest maximum concentration (since 2009) measured in 2013. Confidence intervals calculated for these 1-year average concentrations indicate that the measurements collected are highly variable, particularly between 2010 and 2012.

Figure 16-15. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at DEMI



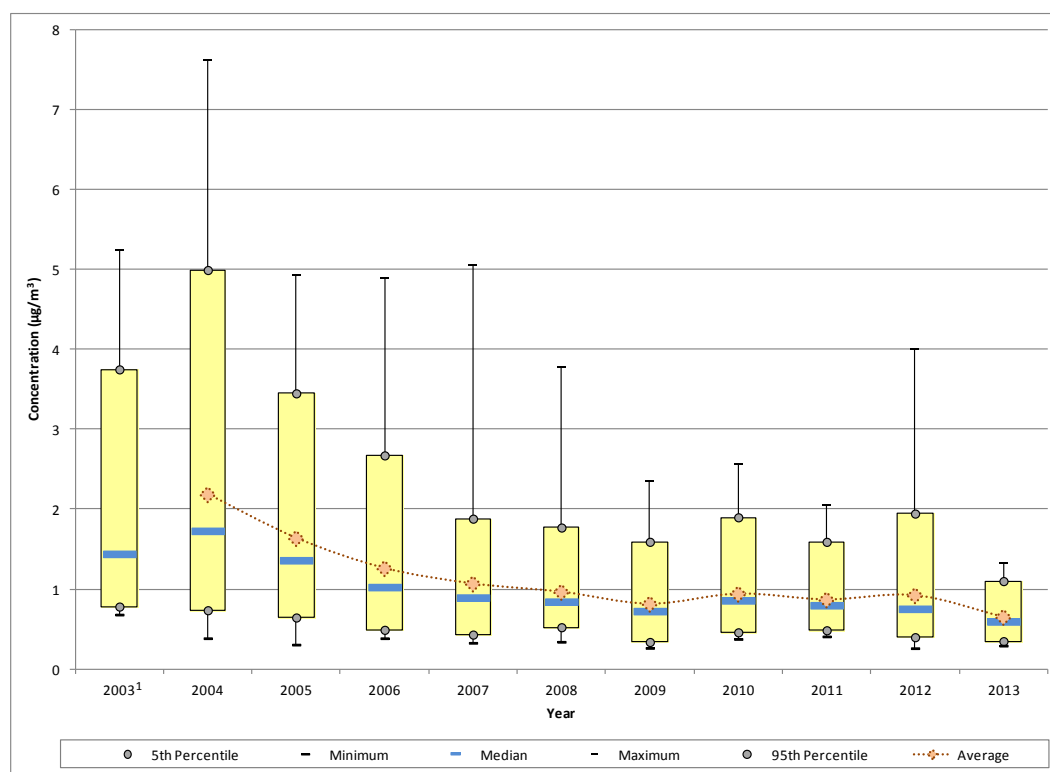
¹ A 1-year average is not presented because data from March 2007 to March 2008 was invalidated.

Observations from Figure 16-15 for acetaldehyde measurements collected at DEMI include the following:

- Carbonyl compounds have been sampled continuously at DEMI under the NMP since 2003, beginning with a 1-in-12 day schedule in 2003 then changing to a 1-in-6 day schedule in the spring of 2004.
- Carbonyl compound samples from the primary sampler were invalidated between March 13, 2007 and March 25, 2008 by the state of Michigan due to a leak in the sample line. With only 12 valid samples in 2007, no statistical metrics are provided. Because less than 75 percent of the samples were valid in 2008, a 1-year average is not presented for 2008, although the range of measurements is provided.
- The maximum acetaldehyde concentration was measured in 2004 ($7.84 \mu\text{g}/\text{m}^3$). Of the six concentrations greater than $5 \mu\text{g}/\text{m}^3$ measured at DEMI, three were measured in 2004, two were measured in 2005, and one was measured in 2006 (and none in the years that follow).
- The 1-year average concentration exhibits a decreasing trend after 2004 that continues through 2006. The median concentration, which is available for 2008, changed little from 2006 to 2008, but decreased slightly for 2009. Both the 1-year average and median concentrations exhibit an increasing trend after 2009 that levels off for 2012, although these changes are not statistically significant.

- The smallest range of acetaldehyde concentrations was measured at DEMI in 2013, yet the median exhibits a considerable increase and is greater than the 1-year average concentration, which is at its highest since 2005. The number of measurements in the $1.75 \mu\text{g}/\text{m}^3$ to $2.75 \mu\text{g}/\text{m}^3$ range increased from 21 to 32 from 2012 to 2013 (accounting for more than half of the measurements in 2013) while the number greater than $2.75 \mu\text{g}/\text{m}^3$ decreased from five to one.

Figure 16-16. Yearly Statistical Metrics for Benzene Concentrations Measured at DEMI



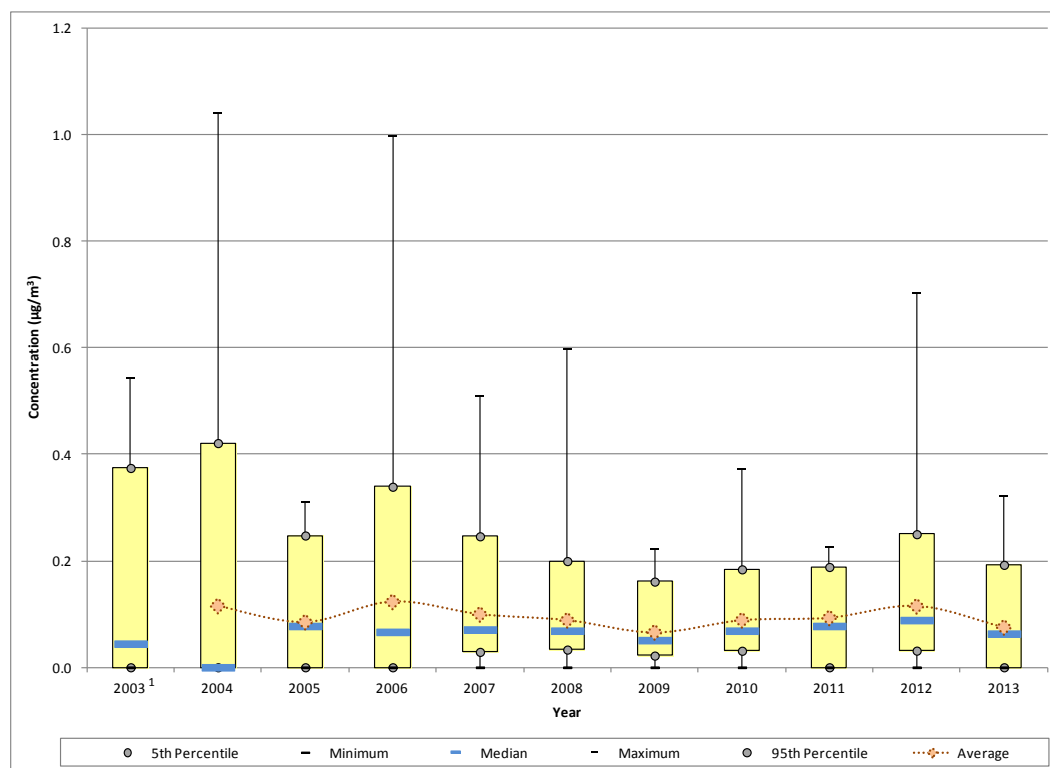
¹ A 1-year average is not presented due to low completeness for 2003.

Observations from Figure 16-16 for benzene measurements collected at DEMI include the following:

- VOCs have been sampled continuously at DEMI under the NMP since 2003. However, the 1-in-12 day schedule in 2003 combined with a number of invalid samples resulted in low completeness; as a result, a 1-year average concentration is not presented for 2003.
- The three highest benzene concentrations were all measured in 2004 and ranged from $5.44 \mu\text{g}/\text{m}^3$ to $7.62 \mu\text{g}/\text{m}^3$. Only two other concentrations greater than $5 \mu\text{g}/\text{m}^3$ have been measured at DEMI, one in 2003 and one in 2007.
- Both the 1-year average and median concentrations exhibit a steady decreasing trend between 2004 and 2009. Between 2009 and 2012, the 1-year average concentration fluctuated between $0.81 \mu\text{g}/\text{m}^3$ (2009) and $0.94 \mu\text{g}/\text{m}^3$ (2010).

- The smallest range of benzene concentrations was measured at DEMI in 2013, for which all of the statistical metrics decreased except the minimum concentration. Both the 1-year average and median concentrations are at a minimum for 2013, representing a significant decrease from previous years.

Figure 16-17. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at DEMI



¹ A 1-year average is not presented due to low completeness for 2003.

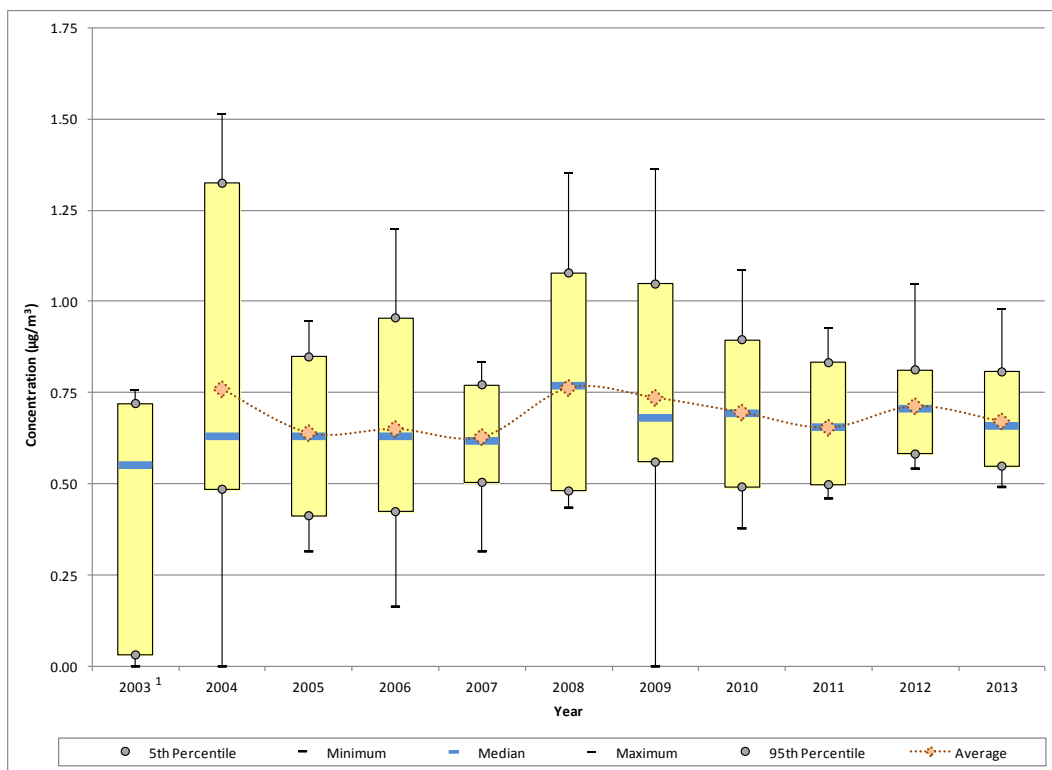
Observations from Figure 16-17 for 1,3-butadiene measurements collected at DEMI include the following:

- The maximum 1,3-butadiene concentration ($1.04 \mu\text{g}/\text{m}^3$) was measured on October 18, 2004 and is the only 1,3-butadiene concentration greater than $1 \mu\text{g}/\text{m}^3$ measured at DEMI, although concentrations greater than $0.90 \mu\text{g}/\text{m}^3$ were measured in 2004 and 2006.
- For 2004, the minimum, 5th percentile, and median concentrations are all zero, indicating that at least half of the measurements were non-detects. Yet, two of the three highest concentrations were also measured at DEMI in 2004; in addition, the maximum 95th percentile was calculated for 2004. This indicates there is a high level of variability within the measurements.
- There were fewer non-detects in 2005 and 2006, as indicated by the increase in the median concentration, and even fewer in the years that follow, as indicated by the increase in the 5th percentile. The percentage of non-detects decreased from a high of

60 percent in 2004 to 2 percent in 2008, then fluctuated between 2 percent and 8 percent for the years that follow. The number of non-detects measured in 2013 (five) is the highest number of non-detects since 2006.

- Even as the number of non-detects decreased (and thus, the number of zeros factored into the calculated decreased), the 1-year average concentration decreased by almost half between 2006 and 2009. This was followed by an increasing trend between 2009 and 2012.
- The 1-year average concentration decreased significantly from 2012 to 2013, as did the median, both of which are at their lowest since 2010.

Figure 16-18. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at DEMI



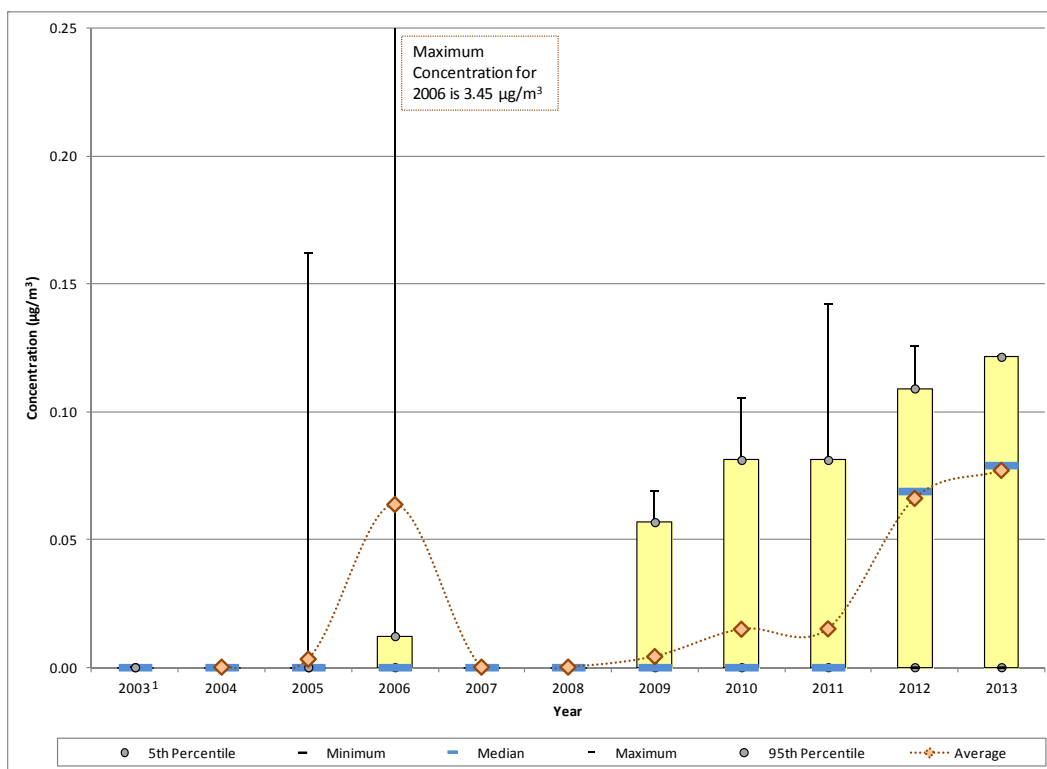
¹ A 1-year average is not presented due to low completeness for 2003.

Observations from Figure 16-18 for carbon tetrachloride measurements collected at DEMI include the following:

- In 2003, the measured detections ranged from 0.32 $\mu\text{g}/\text{m}^3$ to 0.76 $\mu\text{g}/\text{m}^3$, plus two non-detects. This is the only year of sampling for which nearly half the measurements were less than 0.5 $\mu\text{g}/\text{m}^3$.
- The range of concentrations measured in 2004 doubled from 2003 levels. The number of measurements greater than 1 $\mu\text{g}/\text{m}^3$ increased from none in 2003 to 12 for 2004.

- The 1-year average concentration decreased by more than $0.1 \mu\text{g}/\text{m}^3$ from 2004 to 2005, as the range of concentrations measured decreased substantially. Little change in the 1-year average concentration is shown from 2005 to 2007, despite the differences in the ranges of concentrations measured.
- With the exception of the 5th percentile, all of the statistical metrics increased significantly for 2008, with the 1-year average and median concentrations for 2008 similar to the 95th percentile for 2007.
- A steady decreasing trend in the 1-year average concentration is shown between 2008 and 2011. Between these years, the majority of concentrations fell within a tighter concentration range, as indicated by the difference between the 5th and 95th percentiles. For 2012, the difference between the 5th and 95th percentiles is less than $0.25 \mu\text{g}/\text{m}^3$, even though an increase in the 1-year average and median concentrations is shown.
- Most of the statistical parameters exhibit a slight decrease from 2012 to 2013.

Figure 16-19. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at DEMI

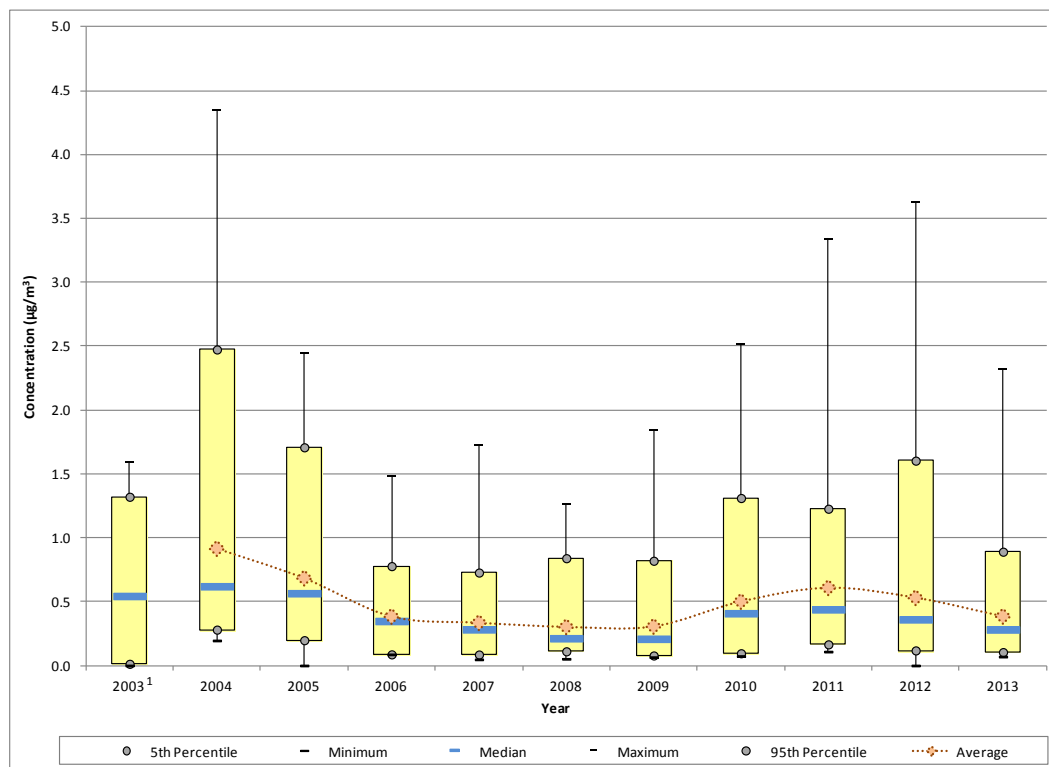


¹ A 1-year average is not presented due to low completeness for 2003.

Observations from Figure 16-19 for 1,2-dichloroethane measurements collected at DEMI include the following:

- There were no measured detections of 1,2-dichloroethane in 2003, 2004, 2007, or 2008. Through 2011, the median concentration is zero for all years, indicating that at least half of the measurements are non-detects: there was only one measured detection in 2005, three in 2006, four in 2009, 12 in 2010, and 11 in 2011. The number of measured detections increased by a factor of five for 2012, with a similar percentage in 2013.
- As the number of measured detections increase, so do each of the corresponding statistical metrics shown in Figure 16-19.
- As the number of measured detections increased dramatically for 2012, the 1-year average and median concentrations increased correspondingly. The median concentration is greater than the 1-year average concentration for 2012. This is because there were still 10 non-detects (or zeros) factoring into the 1-year average concentration for the year, which can pull down an average in the same manner an outlier can drive an average upward.
- The statistical metrics for 2013 resemble those calculated for 2012. The maximum concentration measured in 2013 is very similar to the 95th percentile, such that it appears there is no maximum concentration indicator for 2013.
- The maximum 1,2-dichloroethane concentration measured at DEMI was measured on July 16, 2006 ($3.45 \mu\text{g}/\text{m}^3$). The next highest concentration was also measured in 2006 but was considerably less ($0.16 \mu\text{g}/\text{m}^3$). A similar concentration was also measured in 2005. All of the 10 remaining concentrations greater than $0.1 \mu\text{g}/\text{m}^3$ were measured between 2011 and 2013.

Figure 16-20. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at DEMI



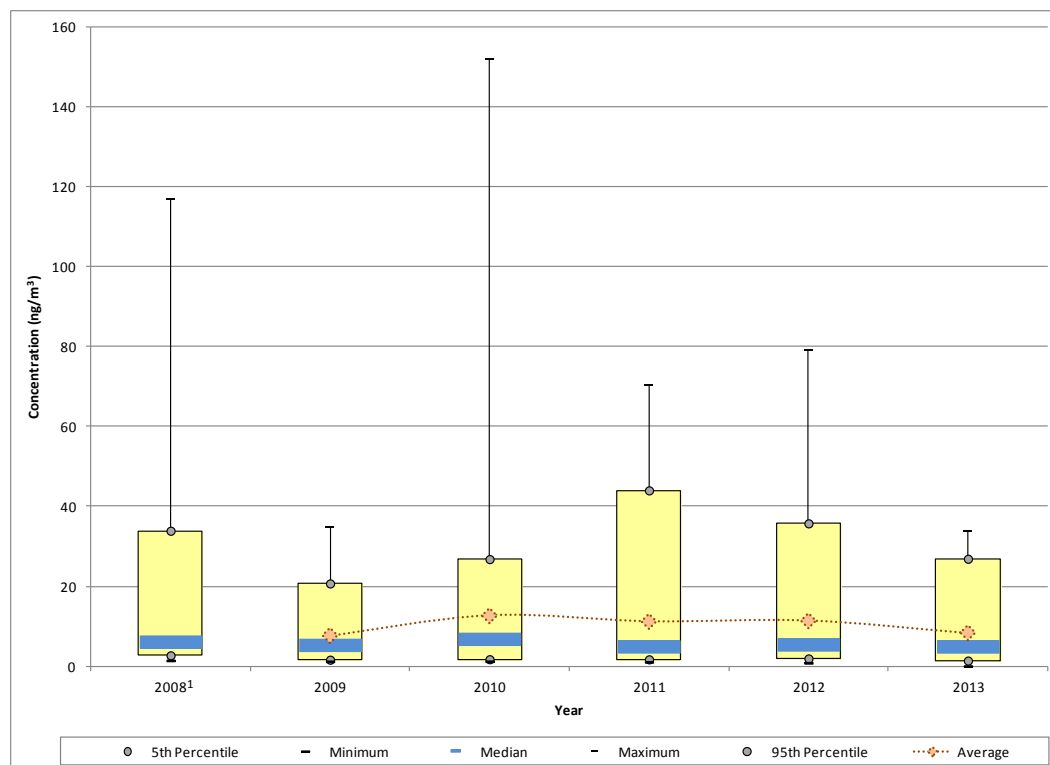
¹ A 1-year average is not presented due to low completeness for 2003.

Observations from Figure 16-20 for ethylbenzene measurements collected at DEMI include the following:

- The maximum ethylbenzene concentration was measured at DEMI in September 2004 ($4.35 \mu\text{g}/\text{m}^3$). Only two other ethylbenzene concentrations greater than $3 \mu\text{g}/\text{m}^3$ have been measured at DEMI (one each in 2011 and 2012). Only 11 concentrations greater than $2 \mu\text{g}/\text{m}^3$ have been measured at DEMI.
- A steady decreasing trend in the 1-year average concentration is shown after 2004, although the rate of decrease levels out after 2006, with the 1-year average reaching a minimum for 2008 ($0.30 \mu\text{g}/\text{m}^3$). Little change is shown for 2009.
- The maximum concentration measured exhibits a steady increasing trend between 2008 and 2012, with all of the statistical parameters exhibiting increases for 2010, with most continuing this increase for 2011.
- For 2012, the minimum concentration decreased (as one non-detect was measured) while the maximum concentration increased. The number of concentrations at the lower end of the concentration range (those less than $0.25 \mu\text{g}/\text{m}^3$) nearly doubled from 2011 to 2012 (up from 10 to 19), resulting in the slight decreases shown in the central tendency statistics for 2012.

- For 2013, all of the statistical metrics exhibit decreases, with the exception of the minimum concentration, as there were no non-detects measured in 2013. The concentrations less than $0.25 \mu\text{g}/\text{m}^3$ account for an even greater percentage of the measurements, accounting for 26 of the measurements (or more than 40 percent) for 2013.

Figure 16-21. Yearly Statistical Metrics for Fluorene Concentrations Measured at DEMI



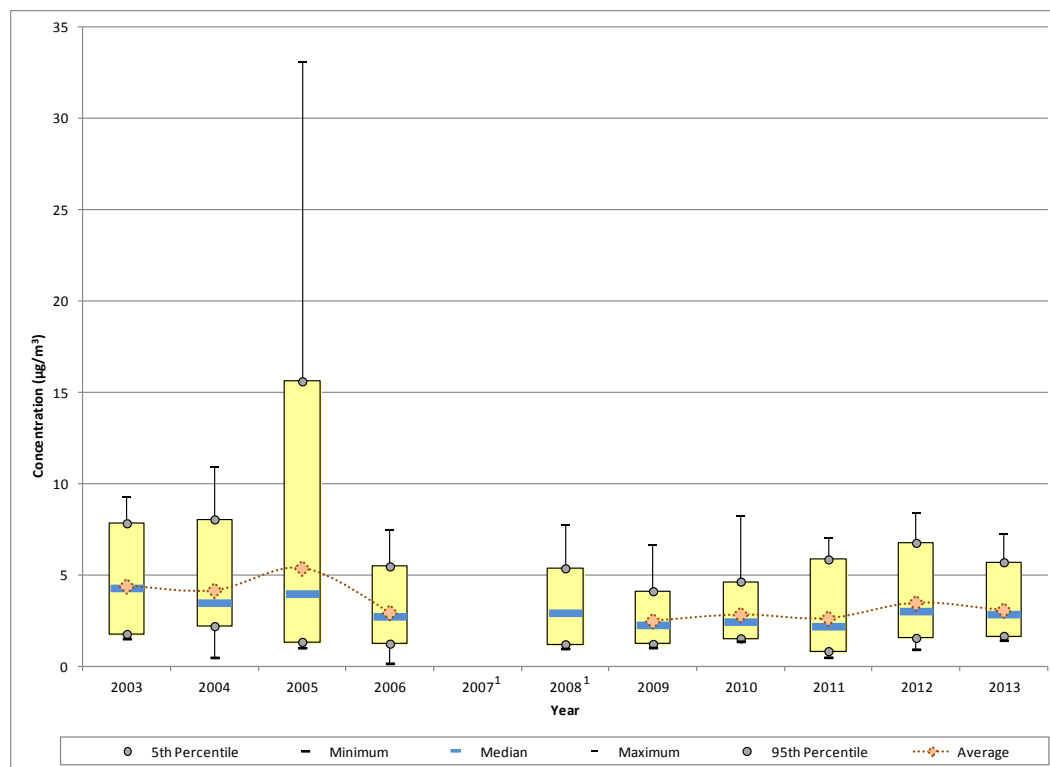
¹ A 1-year average is not presented because sampling under did not begin until April 2008.

Observations from Figure 16-21 for fluorene measurements collected at DEMI include the following:

- The maximum fluorene concentration ($152 \text{ ng}/\text{m}^3$) was measured at DEMI on August 18, 2010 (on the same day as the maximum acenaphthene concentration was measured). Only two other measurements greater than $100 \text{ ng}/\text{m}^3$ have been measured at DEMI (one in August 2008 and another in August 2010). All eight concentrations greater than $50 \text{ ng}/\text{m}^3$ have been measured in June, July, or August and all 38 concentrations greater than $20 \text{ ng}/\text{m}^3$ were measured at DEMI during the second or third quarters of the year (the warmer months of the year), similar to acenaphthene.
- The trends graph for fluorene resembles the trends graph for acenaphthene in Figure 16-14.

- The median concentrations have varied less than 2 ng/m³ over the years, ranging from 4.91 ng/m³ (2013) to 6.82 ng/m³ (2010). The 1-year average concentrations exhibit more variability, ranging from 7.68 ng/m³ (2009) to 12.62 ng/m³ (2010).
- All of the statistical metrics increased (at least slightly) from 2009 to 2010. The 1-year average concentration is being driven by the two highest concentrations measured in 2010 (both greater than 100 ng/m³). The next highest concentration measured in 2010 is considerably less (44.8 ng/m³). If the two highest concentrations were excluded from the calculation, the 1-year average concentration would fall from 12.62 ng/m³ to 8.40 ng/m³.
- The 95th percentile increased steadily between 2009 and 2011. The number of concentrations greater than 25 ng/m³ increased from one to three to six during this period. There were seven concentrations greater than 25 ng/m³ measured in 2012, even though the 95th percentile exhibits a slight decrease.
- All of the statistical parameters exhibit decreases from 2012 to 2013. The maximum concentration measured in 2013 is less than the 95th percentile for 2012 (similar to acenaphthene).

Figure 16-22. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at DEMI

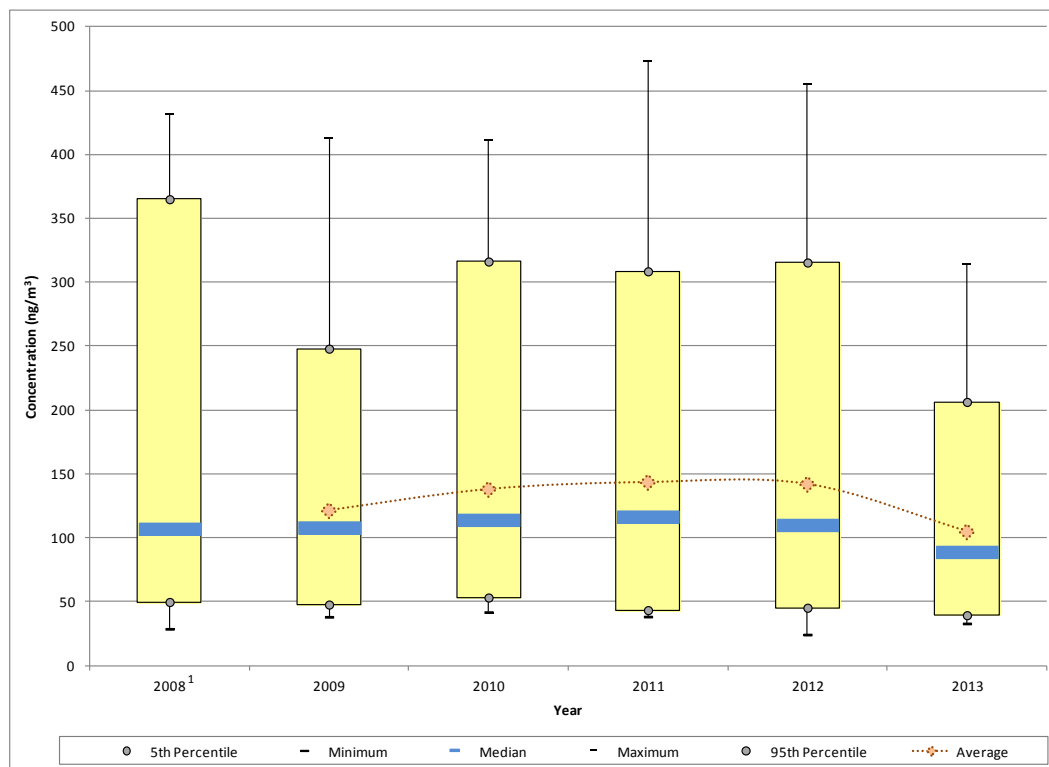


¹ A 1-year average is not presented because data from March 2007 to March 2008 was invalidated.

Observations from Figure 16-22 for formaldehyde measurements collected at DEMI include the following:

- Recall that carbonyl compounds have been sampled continuously at DEMI under the NMP since 2003 but due to a leak in the sample line, samples collected between March 13, 2007 through March 25, 2008 were invalidated. With only 12 valid samples in 2007, no statistical metrics are provided. Because less than 75 percent of the samples were valid in 2008, a 1-year average concentration is not presented for 2008, although the range of measurements is provided.
- The five highest concentrations measured at DEMI were measured in 2005 and ranged from 13.3 $\mu\text{g}/\text{m}^3$ to 33.1 $\mu\text{g}/\text{m}^3$. The nine highest formaldehyde concentrations (those greater than 9 $\mu\text{g}/\text{m}^3$) were measured during the first 3 years of sampling.
- The decrease in the 1-year average concentration shown between 2005 and 2006 is significant (from 5.35 $\mu\text{g}/\text{m}^3$ to 2.92 $\mu\text{g}/\text{m}^3$). The 1-year average concentrations for the years following 2006 (where they could be calculated) did not vary significantly through 2011.
- All of the statistical parameters exhibit increases for 2012. A review of the data shows that the measurements collected in 2012 were higher in general compared to 2011. For instance, there were seven measurements less than 1 $\mu\text{g}/\text{m}^3$ in 2011 and only one in 2012. On the higher end of the range, there were nine concentrations greater than 4 $\mu\text{g}/\text{m}^3$ in 2011 compared to 21 in 2012.
- While most of the statistical parameters exhibit decreases for 2013, the minimum concentration measured in 2013 is at its highest since the onset of sampling.

Figure 16-23. Yearly Statistical Metrics for Naphthalene Concentrations Measured at DEMI



¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 16-23 for naphthalene measurements collected at DEMI include the following:

- The maximum naphthalene concentration was measured at DEMI in July 2011 (473 ng/m³); five additional measurements greater than 400 ng/m³ have been measured at DEMI (at least one in each year except 2013).
- With the exception of the maximum concentration, all of the statistical parameters exhibit increases from 2009 to 2010. Little change is shown in the naphthalene concentrations measured at DEMI between 2010 and 2012.
- The smallest range of naphthalene concentrations was measured in 2013, with all of the statistical parameters exhibiting decreases except the minimum concentration. Both the 1-year average and median concentrations are at a minimum for 2013, with the median concentration falling below 100 ng/m³ for the first time.

16.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the Michigan monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

16.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Michigan site and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 16-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Observations from Table 16-6 include the following:

- Formaldehyde has the highest annual average concentration for DEMI, followed by acetaldehyde, carbon tetrachloride, and benzene.
- These four pollutants also have the highest cancer risk approximations for this site, although the order varies. Formaldehyde's cancer risk approximation is the highest (39.59 in-a-million), with all other cancer risk approximations an order of magnitude lower.
- None of the pollutants of interest for DEMI have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation for DEMI is formaldehyde (0.31).

Table 16-6. Risk Approximations for the Michigan Monitoring Site

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Dearborn, Michigan - DEMI						
Acetaldehyde	0.0000022	0.009	61/61	1.76 ± 0.12	3.87	0.20
Benzene	0.0000078	0.03	62/62	0.65 ± 0.06	5.04	0.02
1,3-Butadiene	0.00003	0.002	58/62	0.08 ± 0.01	2.29	0.04
Carbon Tetrachloride	0.000006	0.1	62/62	0.67 ± 0.02	4.02	0.01
1,2-Dichloroethane	0.000026	2.4	57/62	0.08 ± 0.01	2.00	<0.01
Ethylbenzene	0.0000025	1	62/62	0.39 ± 0.10	0.96	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.05 ± 0.31	39.59	0.31
Acenaphthene ^a	0.000088	--	60/60	9.62 ± 2.72	0.85	--
Fluorene ^a	0.000088	--	59/60	8.35 ± 2.13	0.73	--
Naphthalene ^a	0.000034	0.003	60/60	104.57 ± 14.63	3.56	0.03

-- = A Cancer URE or Noncancer RfC is not available.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

16.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively.

Table 16-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 16-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 16-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for DEMI, as presented in Table 16-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 16-7. Table 16-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 16-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Michigan Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Dearborn, Michigan (Wayne County) - DEMI					
Benzene	524.56	Coke Oven Emissions, PM	8.62E-03	Formaldehyde	39.59
Formaldehyde	438.33	Formaldehyde	5.70E-03	Benzene	5.04
Ethylbenzene	338.52	Benzene	4.09E-03	Carbon Tetrachloride	4.02
Acetaldehyde	254.42	POM, Group 5a	3.22E-03	Acetaldehyde	3.87
1,3-Butadiene	79.05	Hexavalent Chromium	2.53E-03	Naphthalene	3.56
Naphthalene	45.78	1,3-Butadiene	2.37E-03	1,3-Butadiene	2.29
Tetrachloroethylene	30.63	Arsenic, PM	2.06E-03	1,2-Dichloroethane	2.00
Trichloroethylene	17.05	Naphthalene	1.56E-03	Ethylbenzene	0.96
Dichloromethane	10.97	Nickel, PM	9.22E-04	Acenaphthene	0.85
POM, Group 2b	9.34	Ethylbenzene	8.46E-04	Fluorene	0.73

Table 16-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Michigan Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Dearborn, Michigan (Wayne County) - DEMI					
Hydrochloric acid	3,022.43	Acrolein	1,456,276.15	Formaldehyde	0.31
Toluene	2,046.58	Hydrochloric acid	151,121.26	Acetaldehyde	0.20
Hexane	1,276.18	Formaldehyde	44,727.33	1,3-Butadiene	0.04
Xylenes	1,255.32	1,3-Butadiene	39,523.56	Naphthalene	0.03
Methanol	1,113.64	Arsenic, PM	31,862.61	Benzene	0.02
Benzene	524.56	Acetaldehyde	28,268.80	Carbon Tetrachloride	0.01
Formaldehyde	438.33	Nickel, PM	21,350.40	Ethylbenzene	<0.01
Ethylene glycol	384.08	Manganese, PM	21,158.92	1,2-Dichloroethane	<0.01
Ethylbenzene	338.52	Benzene	17,485.46		
Acetaldehyde	254.42	Naphthalene	15,259.58		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 16.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 16-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Wayne County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Wayne County are coke oven emissions, formaldehyde, and benzene.
- Five of the highest emitted pollutants in Wayne County also have the highest toxicity-weighted emissions.
- Formaldehyde has the highest cancer risk approximation for DEMI. This pollutant also appears on both emissions-based lists, ranking second for both its quantity emitted and its toxicity-weighted emissions. Benzene, naphthalene, 1,3-butadiene, and ethylbenzene also appear on both emissions-based lists.
- Acetaldehyde has the fourth highest cancer risk approximation for DEMI and is one of the highest emitted pollutants in Wayne County but does not appear among those with the highest toxicity-weighted emissions. This is also true for acenaphthene and fluorene, which are included as part of POM, Group 2b in the NEI.
- Carbon tetrachloride and 1,2-dichloroethane, the two remaining pollutants of interest shown in Table 16-7, do not appear on either emissions-based list.
- Hexavalent chromium has the fifth highest toxicity-weighted emissions for Wayne County. Although this pollutant was sampled for at DEMI (through June 2013), it was not identified as a pollutant of interest for this site.

Observations from Table 16-8 include the following:

- Hydrochloric acid, toluene, and hexane are the highest emitted pollutants with noncancer RfCs in Wayne County. Wayne County is one of the few counties with an NMP site where toluene is not the highest emitted pollutant in the noncancer table. The quantity of emissions for the highest ranking pollutants in Table 16-8 is an order of magnitude higher than the quantity of emissions for the highest ranking pollutants in Table 16-7.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for Wayne County are acrolein, hydrochloric acid, and formaldehyde. Although acrolein was sampled for at DEMI, this pollutant was excluded from the pollutants of interest designation and thus subsequent risk-based screening evaluations due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.
- Four of the highest emitted pollutants in Wayne County also have the highest toxicity-weighted emissions.
- Formaldehyde has the highest noncancer hazard approximation for DEMI (although none of the pollutants of interest have associated noncancer hazard approximations greater than 1.0). Formaldehyde emissions rank seventh highest for Wayne County while the toxicity-weighted emissions rank third (of the pollutants with noncancer RfCs). Acetaldehyde and benzene also appear on all three lists for DEMI.
- Several metals appear among the pollutants with the highest toxicity-weighted emissions for Wayne County. (This was also true for the pollutants with cancer UREs in Table 16-7.) Speciated metals were not sampled for under the NMP through the contract laboratory.

16.6 Summary of the 2013 Monitoring Data for DEMI

Results from several of the data treatments described in this section include the following:

- ❖ *Eighteen pollutants failed screens for DEMI, including three carbonyl compounds, 10 VOCs, and four PAHs, and hexavalent chromium.*
- ❖ *Of the site-specific pollutants of interest, formaldehyde and acetaldehyde had the highest annual average concentrations for DEMI. None of the other site-specific pollutants of interest had annual average concentrations greater than 1 µg/m³.*
- ❖ *DEMI has the third highest annual average concentration of acenaphthene and the fifth highest annual average concentration naphthalene among NMP sites sampling PAHs.*
- ❖ *Concentrations of formaldehyde, acenaphthene, and fluorene measured at DEMI were highest during the warmer months of the year.*

- ❖ *A significant decrease in benzene concentrations occurred at DEMI for many years, although concentrations have leveled off in recent years. The detection rate of 1,2-dichloroethane has been increasing steadily at DEMI over the last few years of sampling.*

17.0 Site in Minnesota

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP site in Minnesota, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

17.1 Site Characterization

This section characterizes the monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The STMN site is located in St. Cloud, Minnesota. Figure 17-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 17-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 17-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 17-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 17-1. St. Cloud, Minnesota (STMN) Monitoring Site



Figure 17-2. NEI Point Sources Located Within 10 Miles of STMN

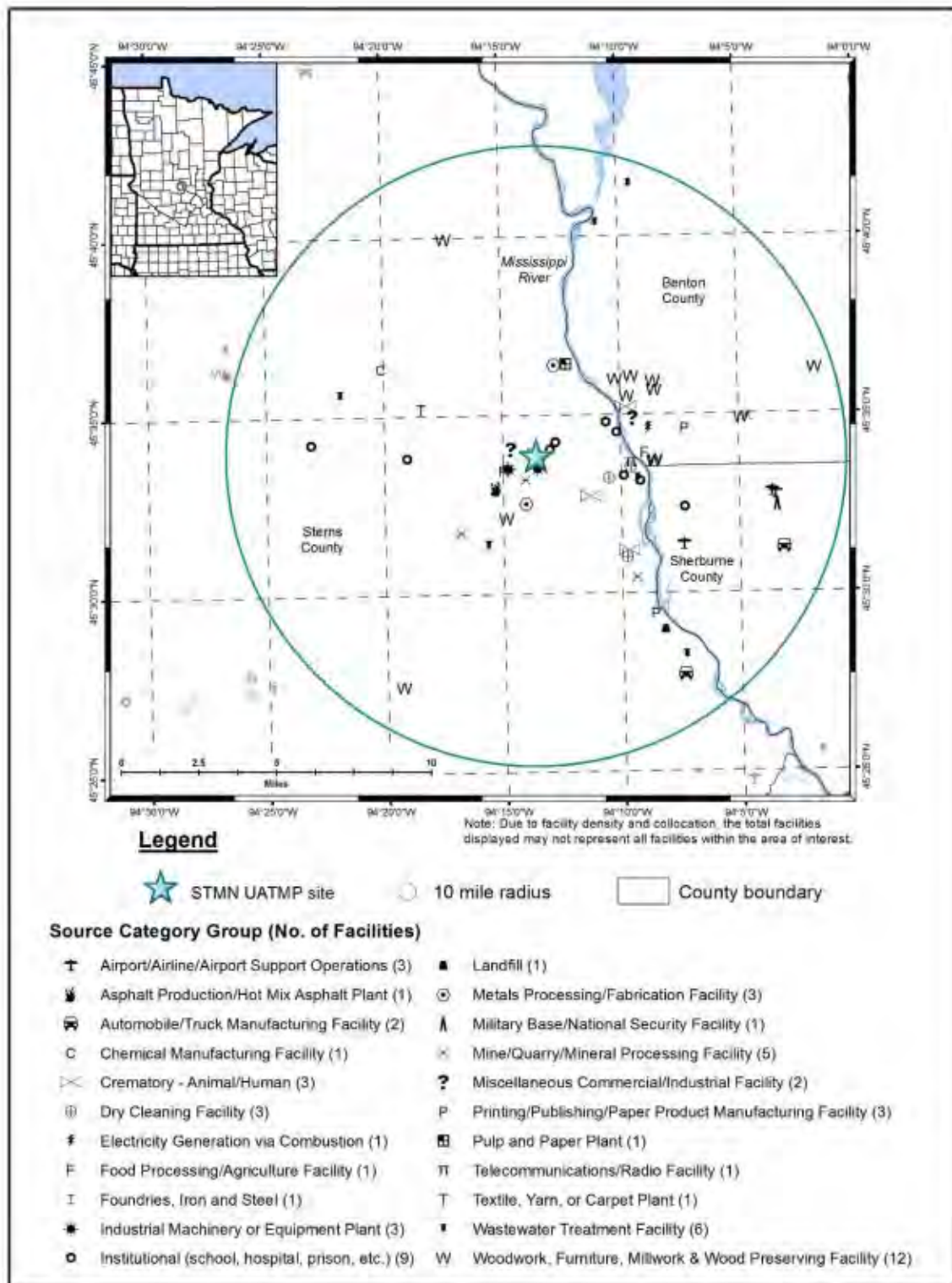


Table 17-1. Geographical Information for the Minnesota Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
STMN	27-145-3053	St. Cloud	Stearns	St. Cloud, MN	45.564637, -94.226345	Industrial	Suburban	TSP, TSP Metals.

¹Data for additional pollutants are reported to AQS for STMN (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

The STMN monitoring site is located on the property of Grede Foundries, St. Cloud, Inc., on the west side of St. Cloud, Minnesota, just north of the Waite Park town limits. Monitoring at this site is source-oriented and part of a special assessment initiated based on elevated total chromium levels (MPCA, 2013). An apartment complex and mobile home park are separated from additional industrial properties, including a stainless steel tank manufacturing facility, by 54th Avenue North just west of the site. Farther west, the Sauk River runs northeast-southwest through the area and is adjacent to additional residential properties to the north and northwest of the site. A railway runs east-west to the south of the site with commercial properties immediately adjacent.

Figure 17-2 shows that the monitoring site is located in close proximity to many emissions sources. The source categories with the greatest number of emissions sources near STMN include woodworking, institutions (which include schools, prisons, and hospitals), wastewater treatment, and mine/quarry/mineral processing. The sources located to the east and along the county boundary are located near the banks of the Mississippi River. The STMN site is located in a highly industrial area, which includes a major hospital to the northeast, a metals processing and fabrication facility, a foundry, iron, and steel facility, and an industrial machinery/equipment plant. Additional facilities are located to the southwest and south.

Table 17-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Minnesota monitoring site. Table 17-2 includes both county-level population and vehicle registration information. Table 17-2 also contains traffic volume information for STMN as well as the location for which the traffic volume was obtained. Additionally, Table 17-2 presents the county-level daily VMT for Stearns County.

Table 17-2. Population, Motor Vehicle, and Traffic Information for the Minnesota Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
STMN	Stearns	152,092	221,636	24,100	8th St N (Route 4/Veterans Dr), at Anderson Ave	5,078,055

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2013 data (MN DPS, 2014)

³AADT reflects 2009 data (MN DOT, 2012)

⁴County-level VMT reflects 2013 data (MN DOT, 2014)

Observations from Table 17-2 include the following:

- The Stearns County population is in the bottom-third compared to other counties with NMP sites. The county-level vehicle registration has a similar ranking compared to other counties with NMP sites.
- The traffic volume near STMN is in the middle of the range compared to other NMP sites. The traffic estimate provided is for 8th Street North (Veterans Drive), east of Anderson Avenue.
- The daily VMT for Stearns County is greater than 5 million miles and ranks 34th compared to other counties with NMP sites.

17.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Minnesota on sample days, as well as over the course of the year.

17.2.1 Climate Summary

The city of St. Cloud is located roughly in the center of the state of Minnesota. The area experiences a continental climate, with summers characterized by warm days and cool nights and winters that are long and cold. Annual precipitation is around 30 inches with more than half of the precipitation concentrated between May and September and in the form of thunderstorms. Nearly 50 inches of snow falls on average during the winter months, with blizzard conditions developing twice per winter (on average). A northwest wind is predominant in St. Cloud most of the year, although a southerly wind occurs during the summer months (NCDC, 2015; MCWG, 2015).

17.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Minnesota monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station to STMN is located at St. Cloud Regional Airport (WBAN 14926). Additional information about the St. Cloud Regional Airport weather station, such as the distance between the site and the weather station, is provided in Table 17-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 17-3. Average Meteorological Conditions near the Minnesota Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
St. Cloud, Minnesota - STMN									
St. Cloud Regional Airport 14926 (45.54, -94.05)	8.6 miles 100° (E)	Sample Days (25)	38.2 ± 7.4	30.6 ± 7.0	20.8 ± 6.3	27.0 ± 6.2	70.4 ± 5.7	1018.9 ± 2.5	7.0 ± 0.9
		2013	50.4 ± 2.6	41.3 ± 2.5	32.0 ± 2.3	37.3 ± 2.3	72.3 ± 1.1	1017.4 ± 0.8	6.9 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 17-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 17-3 is the 95 percent confidence interval for each parameter. As shown in Table 17-3, average meteorological conditions on sample days appear cooler and drier than conditions experienced throughout 2013. Sampling at STMN under the NMP was discontinued at the end of May 2013, thereby missing the warmest and wettest months of the year. Based on the full-year averages, STMN is located in one of the coldest locations, with the second lowest average maximum temperature and third lowest average temperature. This location is also among the driest locations, based on the average dew point and wet bulb temperatures, although the average relative humidity ranks among the higher averages.

17.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at St. Cloud Regional Airport near STMN were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

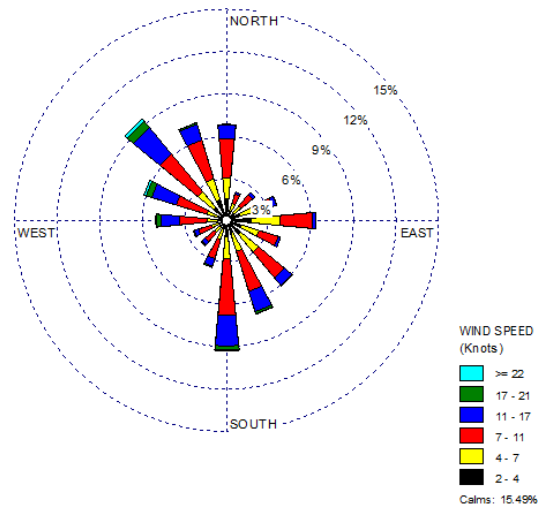
Figure 17-3 presents a map showing the distance between the weather station and STMN, which may be useful for identifying topographical influences that can affect the meteorological patterns experienced at this location. Figure 17-3 also presents three different wind roses for the STMN monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 17-3. Wind Roses for the St. Cloud Regional Airport Weather Station near STMN

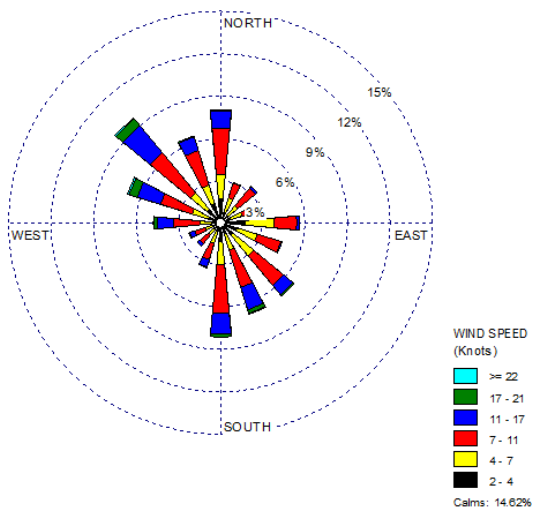
Location of STMN and Weather Station



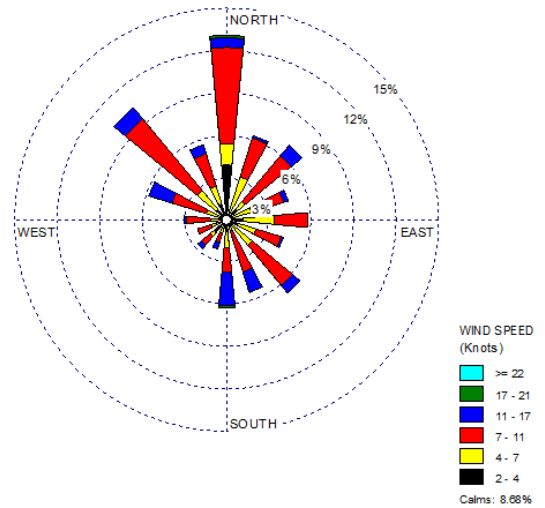
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 17-3 for STMN include the following:

- The St. Cloud Regional Airport weather station is located 8.6 miles east of STMN. Most of the city of St. Cloud and the Mississippi River lie between the site and the weather station. The area surrounding the airport is more rural in nature than the more urbanized area surrounding STMN (although this is more evident in a satellite-type map).
- The historical wind rose shows that winds from the northwest quadrant (including west and north) and southeast quadrant (including east and south) were observed more frequently than winds from the northeast or southwest quadrants. Winds from northwest and south each account for just less than 10 percent of observations. The strongest wind speeds were most often associated with westerly to northwesterly winds. Calm winds (those less than or equal to 2 knots) were observed for more than 15 percent of the hourly measurements.
- The wind patterns shown on the 2013 wind rose resemble the historical wind patterns, indicating that wind observations in 2013 were similar to those observed historically.
- The sample day wind rose exhibits few of the characteristics of the other wind roses, with winds from the north accounting for the greatest percentage of observations. Winds from the northeast quadrant were observed nearly as often as winds from the southeast quadrant and the percentage of calm winds was reduced by nearly half. However, the sample day wind rose includes observations from January through May only and a wind rose with a full year's worth of sample day observations may look different.

17.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for STMN in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 17-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 17-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Only hexavalent chromium was sampled for at STMN.

Table 17-4. Risk-Based Screening Results for the Minnesota Monitoring Site

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
St. Cloud, Minnesota - STMN						
Hexavalent Chromium	0.000083	0	8	0.00	0.00	0.00
Total		0	8	0.00		

Observations from Table 17-4 include the following:

- Hexavalent chromium was detected in eight of the 24 valid samples collected at STMN, representing a 33 percent detection rate.
- The eight measured detections of hexavalent chromium measured in 2013 at STMN did not fail any screens.
- By comparison, hexavalent chromium was detected in 39 of the 54 valid samples collected at STMN during the 2012 portion of the monitoring effort (from February to December 2012) and failed a total of six screens.

17.4 Concentrations

This section typically presents various concentration averages used to characterize pollution levels at the monitoring site for each of the site-specific pollutants of interest. However, because there were no failed screens for STMN, this site has no pollutants of interest based on the risk screening process. The short sampling duration also prevents an annual average concentration for hexavalent chromium to be calculated. In order to facilitate a review of the data collected at STMN in 2013, a few statistical calculations are provided in the section that follows. A statistical summary for all of the hexavalent chromium measurements collected at STMN is provided in Appendix O. The concentration comparison and trend analysis were not performed.

17.4.1 2013 Concentration Averages

Quarterly concentration averages were calculated for hexavalent chromium for the Minnesota site, as described above. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average*, which includes all measured detections and substituted zeros for non-detects for the entire year of

sampling, could not be calculated as sampling at STMN was discontinued at the end of May 2013. Quarterly average concentrations for STMN are presented in Table 17-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 17-5. Quarterly Average Concentrations of Hexavalent Chromium for the Minnesota Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
St. Cloud, Minnesota - STMN						
Hexavalent Chromium	8/24	0.007 ± 0.006	0.003 ± 0.004	NA	NA	NA

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations for STMN from Table 17-5 include the following:

- The eight measured detections of hexavalent chromium range from 0.008 ng/m³ to 0.039 ng/m³. This dataset also includes 16 non-detects, which account for two-thirds of the valid samples collected in 2013.
- Six of the eight measured detections were measured in samples collected in January and February (with the other two measured in May). The measurements from all five samples collected in January resulted in measured detections.
- The hexavalent chromium concentrations measured in 2013 are considerably lower than those measured during the 2012 portion of the monitoring effort, when several of the highest measurements of hexavalent chromium were collected. In total, five hexavalent chromium measurements greater than 1 ng/m³ have been collected under the NMP between 2005 and 2012, with three collected at STMN in 2012.
- In June 2012, a nearby facility manufacturing stainless steel storage and processing tanks installed new air pollution control equipment to reduce its emissions, which resulted in a 97 percent decrease in its hexavalent chromium emissions (MPCA, 2015).

17.5 Additional Risk-Based Screening Evaluations

In order to characterize risk at participating monitoring sites, additional risk-based screening evaluations were conducted. Because there were no pollutants of interest identified for STMN and because annual averages could not be calculated for the pollutant sampled for at

STMN, cancer risk and noncancer hazard approximations, as described in Section 3.4.3.3, were not calculated. The risk-based emissions assessment described in Section 3.4.3.4 was still conducted, at least in part, as the emissions can be reviewed independent of concentrations measured.

17.5.1 Risk-Based Emissions Assessment

This section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively, and is intended to help policy-makers prioritize their air monitoring activities. Table 17-6 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 17-6 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. The emissions and toxicity-weighted emissions are shown in descending order in Table 17-6. Table 17-7 presents similar information, but is limited to those pollutants with noncancer toxicity factors. Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. A more in-depth discussion of this analysis is provided in Section 3.4.3.4.

Table 17-6. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Minnesota Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
St. Cloud, Minnesota (Stearns County) - STMN					
Formaldehyde	200.69	Formaldehyde	2.61E-03		
Benzene	187.61	Benzene	1.46E-03		
Acetaldehyde	110.84	1,3-Butadiene	8.61E-04		
Ethylbenzene	63.20	Naphthalene	5.41E-04		
1,3-Butadiene	28.71	POM, Group 5a	2.62E-04		
Naphthalene	15.90	POM, Group 2b	2.62E-04		
1,3-Dichloropropene	12.08	Acetaldehyde	2.44E-04		
Dichloromethane	3.07	POM, Group 2d	1.92E-04		
POM, Group 2b	2.98	POM, Group 3	1.67E-04		
Tetrachloroethylene	2.69	Ethylbenzene	1.58E-04		

Table 17-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Minnesota Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
St. Cloud, Minnesota (Stearns County) - STMN					
Toluene	813.91	Acrolein	434,785.66		
Xylenes	315.44	Formaldehyde	20,478.35		
Hexane	206.04	1,3-Butadiene	14,356.53		
Formaldehyde	200.69	Acetaldehyde	12,315.70		
Benzene	187.61	Cyanide Compounds, PM	6,419.33		
Acetaldehyde	110.84	Benzene	6,253.79		
Methanol	95.35	Lead, PM	6,189.57		
Ethylbenzene	63.20	Naphthalene	5,300.31		
1,1,1-Trichloroethane	36.41	Chlorine	5,240.71		
Ethylene glycol	32.26	Manganese, PM	3,727.64		

Observations from Table 17-6 include the following:

- Formaldehyde, benzene, and acetaldehyde are the highest emitted pollutants with cancer UREs in Stearns County.
- Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Stearns County.
- Seven of the highest emitted pollutants in Stearns County also have the highest toxicity-weighted emissions.
- Hexavalent chromium, which is the only pollutant sampled for at STMN, is not among the highest emitted pollutants or those with the highest toxicity-weighted emissions shown in Table 17-6. Hexavalent chromium ranks 29th for total emissions and 12th for toxicity-weighted emissions.
- Naphthalene and several POM Groups rank among Stearns County's highest toxicity-weighted emissions. PAHs were not sampled for at STMN.
- In the 2012 NMP report, emissions of bis(2-ethylhexyl)phthalate (DEHP) gas ranked highest in Stearns County. The quantity of emissions of this pollutant decreased substantially with the corrections from version 1 to version 2 of the 2011 NEI, ranking 20th for quantity emitted in version 2.

Observations from Table 17-7 include the following:

- Toluene, xylenes, and hexane are the highest emitted pollutants with noncancer RfCs in Stearns County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and 1,3-butadiene.
- Three of the highest emitted pollutants in Stearns County also have the highest toxicity-weighted emissions.
- Again, hexavalent chromium does not appear among the pollutants with the highest emissions or toxicity-weighted emissions. This pollutant's emissions rank 60th and its toxicity-weighted emissions rank 29th (among the pollutants with noncancer RfCs).
- Similar to Table 17-6, the rankings of bis(2-ethylhexyl)phthalate (DEHP) gas decreased substantially with the corrections from version 1 to version 2 of the 2011 NEI.

17.6 Summary of the 2013 Monitoring Data for STMN

Results from several of the data treatments described in this section include the following:

- ❖ *Hexavalent chromium was the only pollutant sampled for at STMN. Sampling was discontinued at this site in May 2013.*
- ❖ *Non-detects account for two-thirds of the hexavalent chromium measurements collected at STMN in 2013, with the measured detections ranging from 0.008 ng/m³ to 0.039 ng/m³.*

18.0 Sites in Mississippi

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP sites in Mississippi, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

18.1 Site Characterization

This section characterizes the Mississippi monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The Mississippi monitoring sites are located in Columbus, Mississippi. Figures 18-1 and 18-2 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites and their immediate surroundings. Figure 18-3 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 18-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 18-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 18-1. Columbus, Mississippi (KMMS) Monitoring Site



Figure 18-2. Columbus, Mississippi (SSMS) Monitoring Site

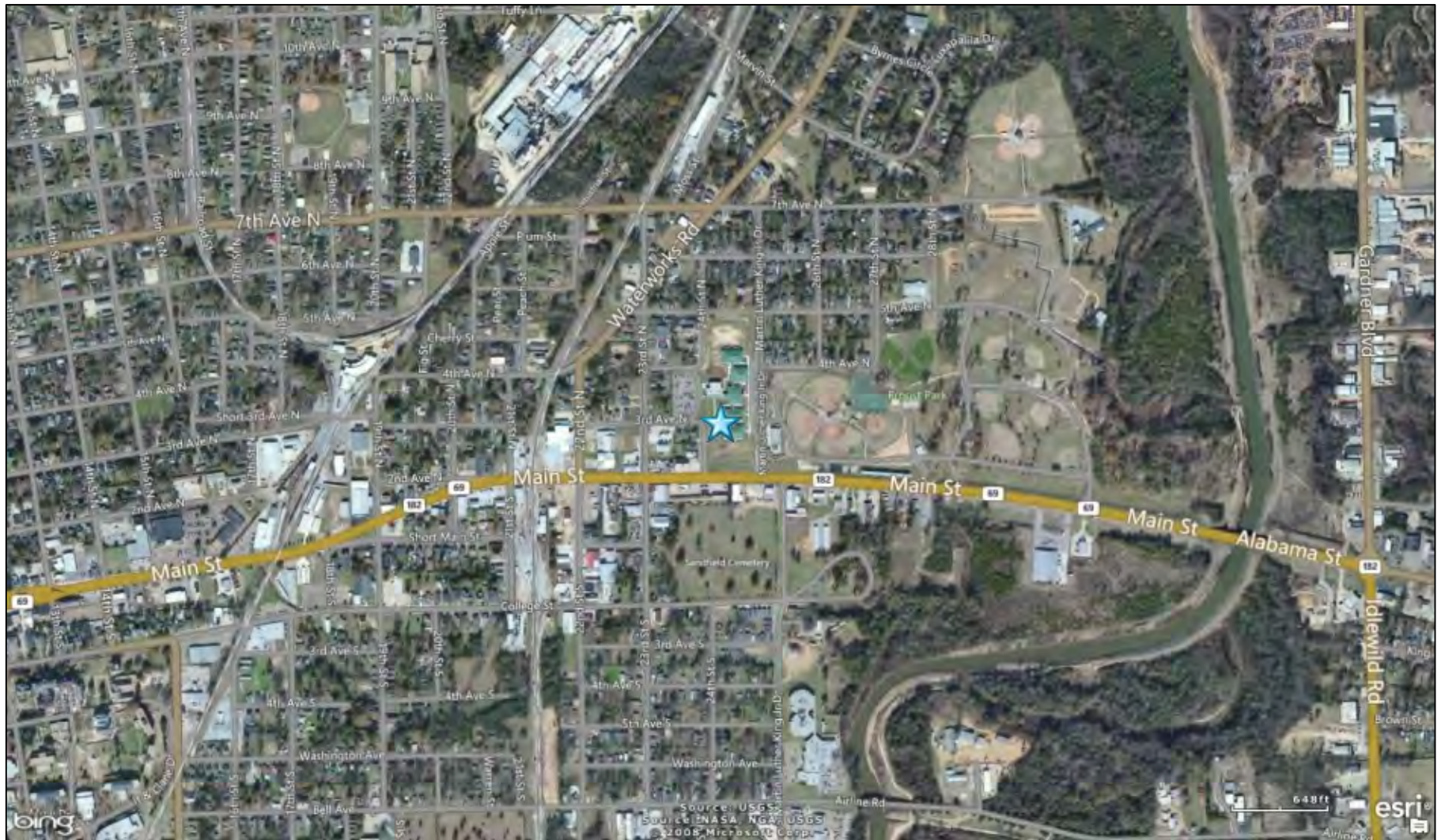


Figure 18-3. NEI Point Sources Located Within 10 Miles of KMMS and SSMS

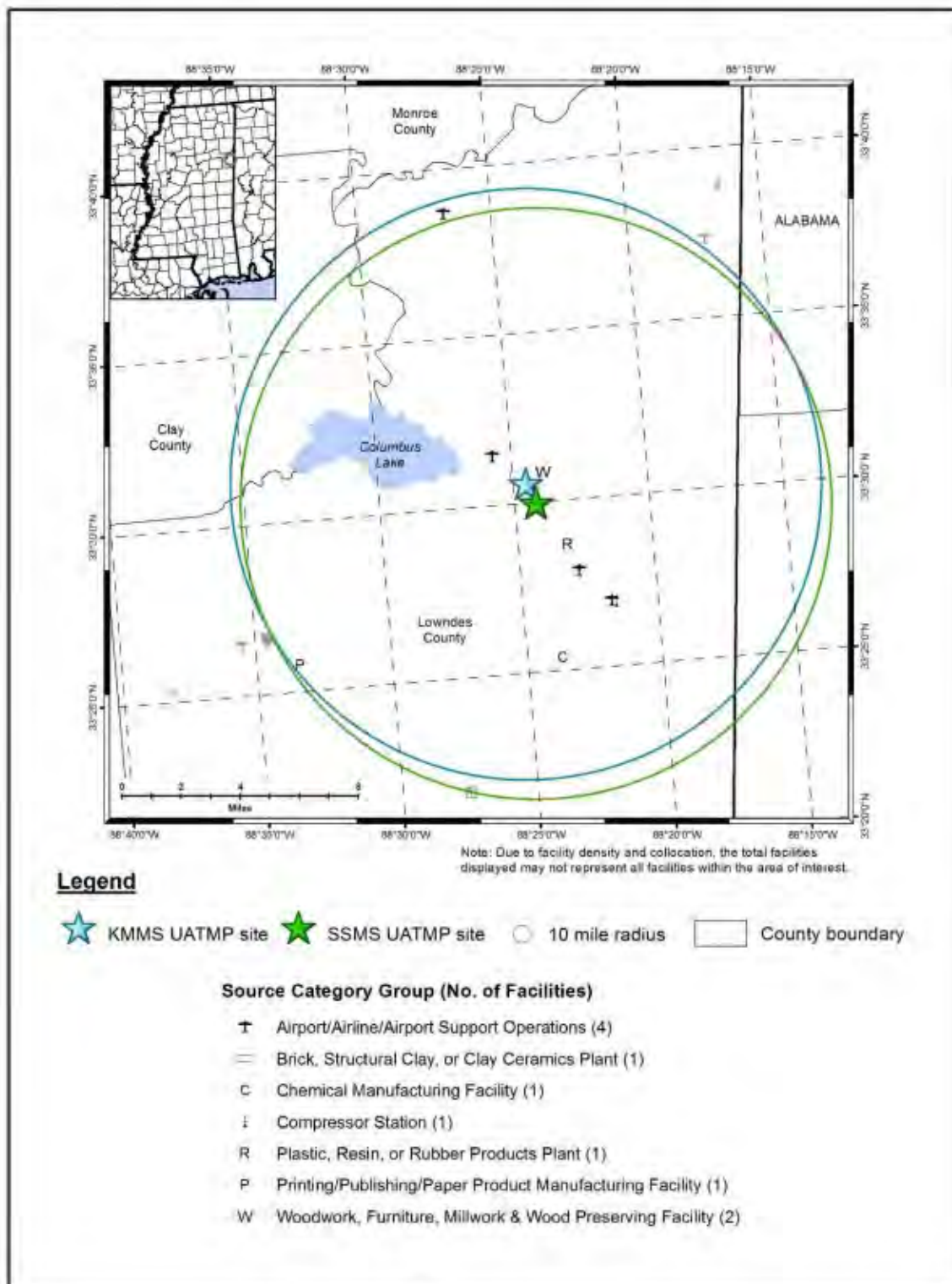


Table 18-1. Geographical Information for the Mississippi Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information
KMMS	28-087-0002	Columbus	Lowndes	Columbus, MS	33.50944, -88.40889	Residential	Urban/City Center	None.
SSMS	28-087-0003	Columbus	Lowndes	Columbus, MS	33.499588, -88.403648	Residential	Urban/City Center	None.

The KMMS and SSMS monitoring sites are located in Columbus, Mississippi. Columbus is located about 7 miles from the Mississippi/Alabama border. One of the sites (KMMS) is located on the property of Kerr-McGee, a former chemical manufacturing facility that pressure-treated wood products such as railroad ties in the northern part of town. The Kerr-McGee property consists of 90 acres. Operations ceased in 2003. The property is a Superfund site and remediation is on-going. Monitoring at these sites is part of an investigation into risk potential associated with soil contamination. More information can be found at EPA's Region 4 Superfund website (EPA, 2015f).

The KMMS site is located on the east side of the Kerr-McGee property. VOC samples were collected at this site throughout the year. PAH sampling occurred at two locations over 6 months: at the primary location for 3 months and at the nearby pine yard for 3 months, a location where treated wood awaited shipment, on the northeast side of the property. Immediately to the south of the property lies a cemetery. Additional industrial facilities are located to the south, northwest, and northeast, with residential areas surrounding the aforementioned areas, as shown in Figure 18-1.

The SSMS monitoring site is located to south of the KMMS site at Stokes-Beard Elementary School, the ball fields of which are prominent features in Figure 18-2. The school is located on Main Street (Route 69/182), a primary thoroughfare through the center of Columbus. Magby Creek runs roughly north-south to the east of both sites. A rail line runs roughly north-south through Columbus, lies just to the east Kerr-McGee property, and about three blocks west of SSMS.

Table 18-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Mississippi monitoring sites. Table 18-2 includes both county-level population and vehicle registration information. Table 18-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 18-2 presents the county-level daily VMT for Lowndes County.

Table 18-2. Population, Motor Vehicle, and Traffic Information for the Mississippi Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
KMMS	Lowndes	59,922	54,826	9,900	N 14th Ave east of N 21st St	1,961,288
SSMS				19,000	Main St east of N 23rd St	

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2013 data (MS DOR, 2014)

³AADT reflects 2013 data (MS DOT, 2013)

⁴County-level VMT reflects 2012 data (MS DOT, 2014)

Observations from Table 18-2 include the following:

- Lowndes County has one of the lower county-level populations compared to other counties with NMP sites. The same is true for the county-level vehicle registration for Lowndes County.
- SSMS experiences a higher traffic volume compared to KMMS. The traffic volume near SSMS is in the middle of the range compared to traffic volumes near other NMP sites, with the traffic volume near KMMS ranking in the bottom third.
- The daily VMT for Lowndes County is nearly 2 million miles, ranking among the lower VMT compared to other counties with NMP sites.

18.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Mississippi on sample days, as well as over the course of the year.

18.2.1 Climate Summary

The state of Mississippi has a humid subtropical climate, with mild winters and long hot summers. Southerly winds prevail much of the year, bringing warm moist air out of the Gulf of Mexico, contributing to high humidity levels. During the winter, warm moist air out of the Gulf of Mexico alternates with cooler, drier air from the north, although cold spells tend to be short-lived. Mississippi is one of the wettest states in the country, with state-wide annual precipitation levels greater than 55 inches. Afternoon thunderstorms occur with regularity and tornadoes are not uncommon (NCDC, 2015).

18.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Mississippi monitoring sites (NCDC, 2013), as described in Section 3.4.2. The closest weather station to both KMMS and SSMS is located at the Columbus Air Force Base Airport (WBAN 13825). Additional information about the Columbus Air Force Base weather station, such as the distance between the sites and the weather station, is provided in Table 18-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 18-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 18-3 is the 95 percent confidence interval for each parameter. As shown in Table 18-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year. These sites experienced the highest relative humidity levels among all NMP sites, one of only two locations with an average relative humidity greater than 75 percent.

18.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at the Columbus Air Force Base Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Table 18-3. Average Meteorological Conditions near the Mississippi Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Columbus, Mississippi - KMMS									
Columbus Air Force Base Airport 13825 (33.65, -88.45)	10.0 miles	Sample Days (63)	72.3 ± 4.0	62.2 ± 4.0	53.4 ± 4.2	57.3 ± 3.8	76.0 ± 2.5	1018.9 ± 1.6	4.9 ± 0.6
	346° (NNW)	2013	72.1 ± 1.6	61.5 ± 1.6	52.7 ± 1.7	56.8 ± 1.5	76.1 ± 1.1	1018.8 ± 0.6	4.6 ± 0.3
Columbus, Mississippi - SSMS									
Columbus Air Force Base Airport 13825 (33.65, -88.45)	10.7 miles	Sample Days (60)	72.0 ± 4.2	61.7 ± 4.1	52.8 ± 4.4	56.9 ± 3.9	75.7 ± 2.6	1019.0 ± 1.6	5.0 ± 0.7
	346° (NNW)	2013	72.1 ± 1.6	61.5 ± 1.6	52.7 ± 1.7	56.8 ± 1.5	76.1 ± 1.1	1018.8 ± 0.6	4.6 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Figure 18-4 presents a map showing the distance between the weather station and KMMS, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 18-4 also presents three different wind roses for the KMMS monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind observations for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 18-5 presents the distance map and three wind roses for SSMS.

Observations from Figures 18-4 and 18-5 for the Mississippi monitoring sites include the following:

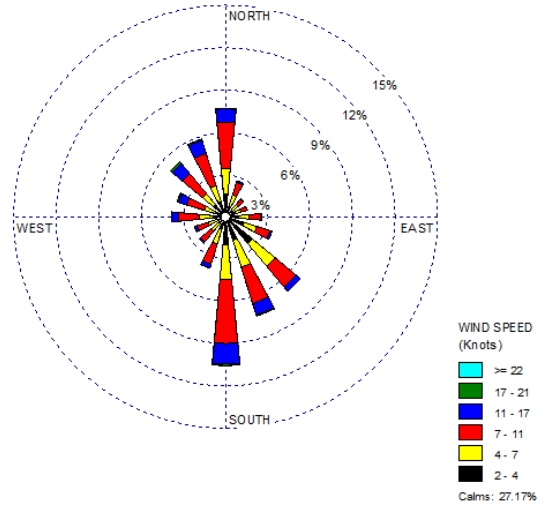
- The weather station at Columbus Air Force Base Airport is the closest weather station to both KMMS and SSMS. The Columbus Air Force Base is located well north of Columbus, 10 miles north-northwest of KMMS and nearly 11 miles north-northwest of SSMS.
- Because the Columbus Air Force Base weather station is the closest weather station to both sites, the historical and 2013 wind roses for KMMS are the same as those for SSMS.
- The historical wind rose shows that winds from the south prevail near KMMS and SSMS. Winds from the southeast to south and northwest to north are the most commonly observed winds observed near the Mississippi sites. Winds from the northeast and southwest quadrants were infrequently observed. Calm winds (those less than or equal to 2 knots) account for 27 percent of the hourly wind measurements from 2003 to 2012.
- The 2013 wind patterns are similar to the historical wind patterns.
- The sample day wind patterns for each site resemble both the historical and 2013 wind patterns, indicating that wind conditions on sample days were representative of those experienced over the entire year and historically. However, northerly winds were observed more frequently on sample days, while calm winds were observed less frequently.

Figure 18-4. Wind Roses for the Columbus Air Force Base Airport Weather Station near KMMS

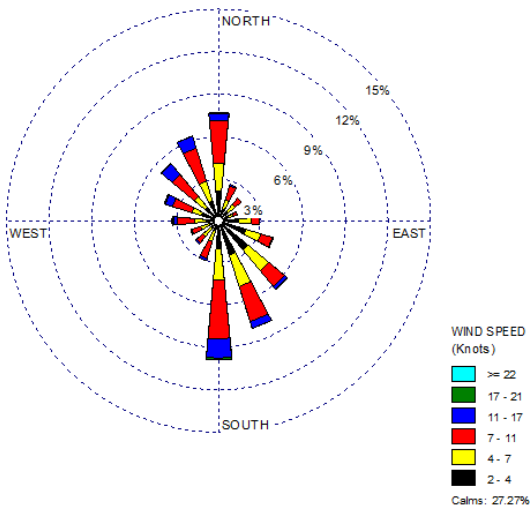
Location of KMMS and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

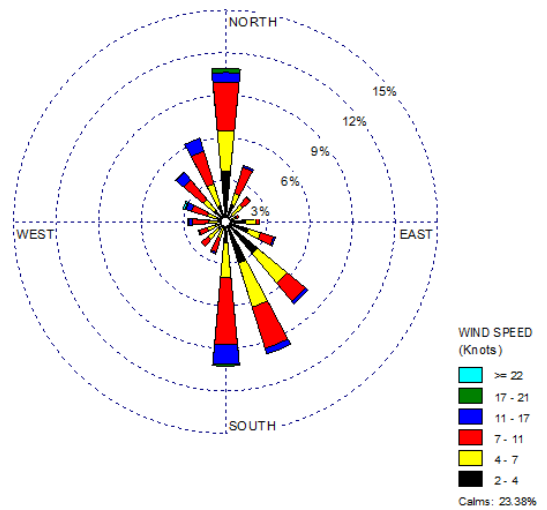
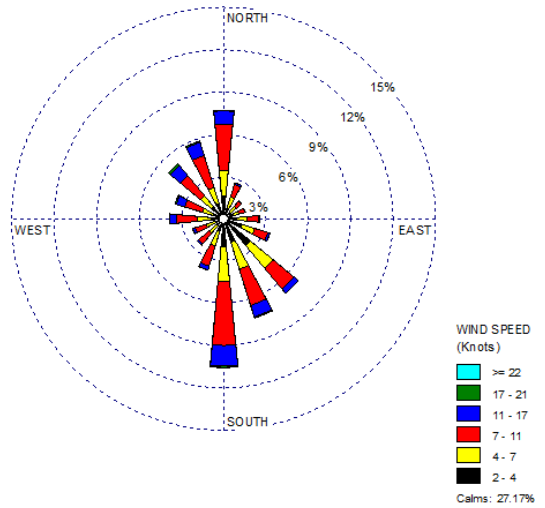


Figure 18-5. Wind Roses for the Columbus Air Force Base Airport Weather Station near SSMS

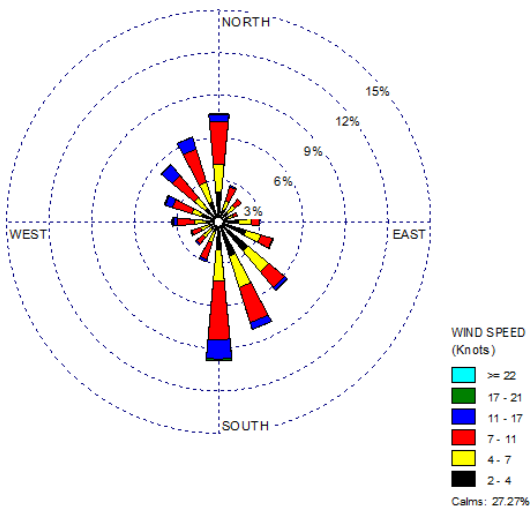
Location of SSMS and Weather Station



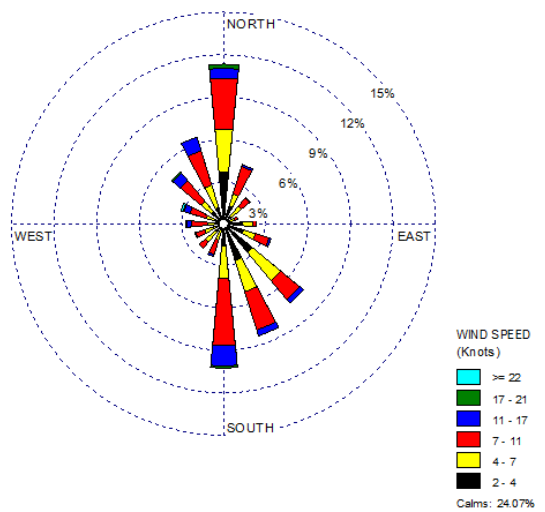
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



18.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Mississippi monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 18-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 18-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. VOCs were sampled for at both Mississippi sites year-round; PAHs were also sampled for at KMMS for a 6-month period from May 10, 2013 to October 31, 2013. However, the PAH instrumentation was moved from near the VOC sampler to the pine yard after August 8, 2013, as mentioned in Section 18.1, which is located north of N 14th Avenue, just west of the rail road (EPA, 2014f). The PAH samples collected at the KMMS site were analyzed using an adjusted methodology in order to provide for the analysis of phenol and cresols at the request of the monitoring agency, as discussed in Section 2.2.3. As a result, the PAH analyte list is slightly different and includes results for phenols and cresols.

Observations from Table 18-4 include the following:

- The number of pollutants failing screens is higher for KMMS than SSMS; this is expected given that PAHs were not sampled for at SSMS.
- Fourteen pollutants failed at least one screen for KMMS; 61 percent of concentrations for these 14 pollutants were greater than their associated risk screening value (or failed screens).
- Ten pollutants contributed to 95 percent of failed screens for KMMS and therefore were identified as pollutants of interest for KMMS. These 10 pollutants include seven VOCs and three PAHs. KMMS is the only NMP site for which xylenes are a pollutant of interest. Xylenes concentrations measured at KMMS account for half of the failed screens of this pollutant across the program.
- Ten pollutants failed screens for SSMS; approximately 64 percent of concentrations for these 10 pollutants were greater than their associated risk screening value (or failed screens).

- Seven pollutants contributed to 95 percent of failed screens for SSMS and therefore were identified as pollutants of interest for this site.
- These sites have six pollutants of interest in common: benzene, 1,3-butadiene, carbon tetrachloride, *p*-dichlorobenzene, ethylbenzene, and 1,2-dichloroethane.
- Benzene, carbon tetrachloride, and 1,2-dichloroethane each failed 100 percent of screens for each site.
- Although both phenol and cresols have screening values, none of these failed screens for KMMS.

Table 18-4. Risk-Based Screening Results for the Mississippi Monitoring Sites

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Kerr-McGee, Columbus, Mississippi - KMMS						
Benzene	0.13	60	60	100.00	17.96	17.96
Carbon Tetrachloride	0.17	60	60	100.00	17.96	35.93
1,2-Dichloroethane	0.038	57	57	100.00	17.07	52.99
1,3-Butadiene	0.03	43	51	84.31	12.87	65.87
Naphthalene	0.029	29	30	96.67	8.68	74.55
Acenaphthene	0.011	20	30	66.67	5.99	80.54
Ethylbenzene	0.4	17	60	28.33	5.09	85.63
<i>p</i> -Dichlorobenzene	0.091	11	39	28.21	3.29	88.92
Fluorene	0.011	11	30	36.67	3.29	92.22
Xylenes	10	11	60	18.33	3.29	95.51
Hexachloro-1,3-butadiene	0.045	10	12	83.33	2.99	98.50
Fluoranthene	0.011	3	30	10.00	0.90	99.40
Trichloroethylene	0.2	1	16	6.25	0.30	99.70
Vinyl chloride	0.11	1	10	10.00	0.30	100.00
Total		334	545	61.28		
Stokes-Beard Elementary School, Columbus, Mississippi - SSMS						
Benzene	0.13	61	61	100.00	21.25	21.25
Carbon Tetrachloride	0.17	61	61	100.00	21.25	42.51
1,2-Dichloroethane	0.038	58	58	100.00	20.21	62.72
1,3-Butadiene	0.03	54	58	93.10	18.82	81.53
<i>p</i> -Dichlorobenzene	0.091	18	48	37.50	6.27	87.80
Hexachloro-1,3-butadiene	0.045	16	19	84.21	5.57	93.38
Ethylbenzene	0.4	14	61	22.95	4.88	98.26
Xylenes	10	3	61	4.92	1.05	99.30
Methyl <i>tert</i> -Butyl Ether	3.8	1	7	14.29	0.35	99.65
Vinyl chloride	0.11	1	11	9.09	0.35	100.00
Total		287	445	64.49		

18.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Mississippi monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual average concentrations are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at KMMS and SSMS are provided in Appendices J and M.

18.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Mississippi monitoring site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Mississippi monitoring sites are presented in Table 18-5, where applicable. Note that concentrations of the PAHs for KMMS are presented in ng/m³ for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 18-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Mississippi Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Kerr-McGee, Columbus, Mississippi - KMMS						
Benzene	60/60	0.74 ± 0.12	0.39 ± 0.05	0.45 ± 0.12	0.55 ± 0.11	0.53 ± 0.06
1,3-Butadiene	51/60	0.07 ± 0.03	0.03 ± 0.02	0.04 ± 0.02	0.09 ± 0.03	0.06 ± 0.01
Carbon Tetrachloride	60/60	0.65 ± 0.03	0.68 ± 0.05	0.66 ± 0.04	0.65 ± 0.02	0.66 ± 0.02
<i>p</i> -Dichlorobenzene	39/60	0.06 ± 0.04	0.04 ± 0.02	0.05 ± 0.02	0.06 ± 0.03	0.05 ± 0.01
1,2-Dichloroethane	57/60	0.10 ± 0.01	0.08 ± 0.01	0.05 ± 0.02	0.08 ± 0.01	0.08 ± 0.01
Ethylbenzene	60/60	1.78 ± 2.07	3.35 ± 3.01	1.82 ± 2.43	0.85 ± 0.99	1.95 ± 1.08
Xylenes	60/60	11.22 ± 14.04	21.66 ± 19.79	11.57 ± 16.35	4.88 ± 6.43	12.33 ± 7.20
Acenaphthene ^a	30/30	NA	NA	19.34 ± 5.21	NA	NA
Fluorene ^a	30/30	NA	NA	11.27 ± 2.77	NA	NA
Naphthalene ^a	30/30	NA	NA	116.30 ± 33.22	NA	NA
Stokes-Beard Elementary School, Columbus, Mississippi - SSMS						
Benzene	61/61	0.80 ± 0.16	0.47 ± 0.08	0.52 ± 0.11	0.63 ± 0.18	0.60 ± 0.07
1,3-Butadiene	58/61	0.10 ± 0.04	0.05 ± 0.02	0.05 ± 0.02	0.11 ± 0.04	0.08 ± 0.02
Carbon Tetrachloride	61/61	0.62 ± 0.04	0.69 ± 0.06	0.69 ± 0.03	0.65 ± 0.04	0.66 ± 0.02
<i>p</i> -Dichlorobenzene	48/61	0.08 ± 0.05	0.06 ± 0.02	0.06 ± 0.02	0.10 ± 0.03	0.08 ± 0.02
1,2-Dichloroethane	58/61	0.10 ± 0.01	0.09 ± 0.01	0.07 ± 0.01	0.07 ± 0.02	0.08 ± 0.01
Ethylbenzene	61/61	0.52 ± 0.35	0.35 ± 0.25	0.24 ± 0.07	0.46 ± 0.24	0.39 ± 0.12
Hexachloro-1,3-butadiene	19/61	0.04 ± 0.03	0.02 ± 0.02	0	0.05 ± 0.02	0.03 ± 0.01

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for KMMS from Table 18-5 include the following:

- The pollutants of interest with the highest annual average concentrations are xylenes ($13.22 \pm 7.20 \mu\text{g}/\text{m}^3$) and ethylbenzene ($1.95 \pm 1.08 \mu\text{g}/\text{m}^3$). These are the only pollutants of interest with an annual average concentration greater than $1 \mu\text{g}/\text{m}^3$ for this site.

- Each of the quarterly average concentrations for xylenes have relatively large confidence intervals associated with them, some of which are greater than the averages themselves. A review of the xylenes data shows that concentrations span three orders of magnitude and range from 0.19 $\mu\text{g}/\text{m}^3$ to 117 $\mu\text{g}/\text{m}^3$. The 10 highest xylenes concentrations measured across the NMP (those greater than 25 $\mu\text{g}/\text{m}^3$) were all measured at KMMS and were measured at various time throughout the year. Half of the concentrations greater than 25 $\mu\text{g}/\text{m}^3$ were measured during the second quarter of 2013, in April and May, with two measured during the first quarter, two during the third quarter, and one during the fourth quarter. The maximum xylenes concentration was measured on April 10, 2013, with a second xylenes concentrations greater than 100 $\mu\text{g}/\text{m}^3$ measured on August 8, 2013. A third concentration approaching 100 $\mu\text{g}/\text{m}^3$ was also measured on April 16, 2013.
- The annual and quarterly average concentrations of ethylbenzene also have large confidence intervals. Concentrations of ethylbenzene measured at KMMS range from 0.0696 $\mu\text{g}/\text{m}^3$ to 18.7 $\mu\text{g}/\text{m}^3$, with nine of the 10 ethylbenzene concentrations greater than 5 $\mu\text{g}/\text{m}^3$ across the program measured at KMMS. The 10 highest ethylbenzene concentrations were measured at KMMS on the same days as the 10 highest xylenes concentrations.
- Concentrations of benzene and 1,3-butadiene measured at KMMS appear higher during the colder months of the year and lower during the warmer months of the year, although the differences among the quarterly average concentrations are not statistically significant.
- Due to the duration of the PAH sampling and the criteria for quarterly averages, only third quarter average concentrations could be calculated, as shown in Table 18-5.
- Of the PAH pollutants of interest, naphthalene had the highest concentrations, spanning an order of magnitude and ranging from 22.1 ng/m^3 to 281 ng/m^3 . Naphthalene concentrations greater than 200 ng/m^3 were measured five times in samples collected between May and August. Concentrations of fluorene ranged from 1.20 ng/m^3 to 23.6 ng/m^3 , with fluorene concentrations greater than 20 ng/m^3 measured four times between May and August. Concentrations of acenaphthene ranged from 1.56 ng/m^3 to 40.3 ng/m^3 , with acenaphthene concentrations greater than 30 ng/m^3 measured five times between May and August. The maximum concentration of all three PAHs was measured on June 21, 2013. The top five concentrations of each were measured on the same 5 days, although the order varied, and were all measured prior to the instrument relocation to the pine yard.

Observations for SSMS from Table 18-5 include the following:

- None of the pollutants of interest for SSMS have an annual average concentration greater than 1 $\mu\text{g}/\text{m}^3$. The pollutant of interest with the highest annual average concentration for SSMS is carbon tetrachloride ($0.66 \pm 0.02 \mu\text{g}/\text{m}^3$), which is equivalent to the annual average concentration of this pollutant for KMMS.

- The annual average concentration of ethylbenzene calculated for SSMS is considerably less than the annual average concentration of ethylbenzene calculated for KMMS. Although several of the quarterly average concentrations have relatively large confidence intervals, they are all considerably less than the quarterly averages calculated for KMMS. Concentrations of ethylbenzene measured at SSMS range from 0.052 $\mu\text{g}/\text{m}^3$ to 2.72 $\mu\text{g}/\text{m}^3$, with concentrations greater than 1 $\mu\text{g}/\text{m}^3$ measured on two different days in January, one in June, and another in November. None of these dates correspond with “high” days for KMMS.
- Similar to KMMS, concentrations of benzene and 1,3-butadiene measured at SSMS appear higher during the colder months of the year, although the differences among the quarterly average concentrations are not statistically significant. A review of the data shows that the five benzene concentrations greater than 1 $\mu\text{g}/\text{m}^3$ were measured at SSMS between January and February or November and December. For 1,3-butadiene, the six highest concentrations were measured in January, February, November or December. Note that the four highest concentrations of benzene and 1,3-butadiene were measured on the same days, although the order varied, with the two highest concentrations of both pollutants measured on December 18, 2013 and January 4, 2013.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for KMMS and SSMS from those tables include the following:

- KMMS and SSMS appear in Table 4-9 a total of six times.
- KMMS has the highest annual average ethylbenzene concentration among NMP sites sampling this pollutant. This site’s annual average concentration is more than twice the next highest concentration of ethylbenzene shown and has the largest confidence interval (by a considerable margin).
- SSMS has the highest annual average concentration of hexachloro-1,3-butadiene among NMP sites sampling this pollutant. This site has the most measured detections of this pollutant (19); in addition, the second and third highest concentrations of this pollutant across the program were measured at SSMS.
- SSMS and KMMS rank fifth and seventh, respectively, for their annual average concentrations of *p*-dichlorobenzene.

18.4.2 Concentration Comparison

In order to better illustrate how each site’s annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 18-4 for KMMS and SSMS. Figures 18-6 through 18-13 overlay the sites’

minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 18-6. Program vs. Site-Specific Average Benzene Concentrations

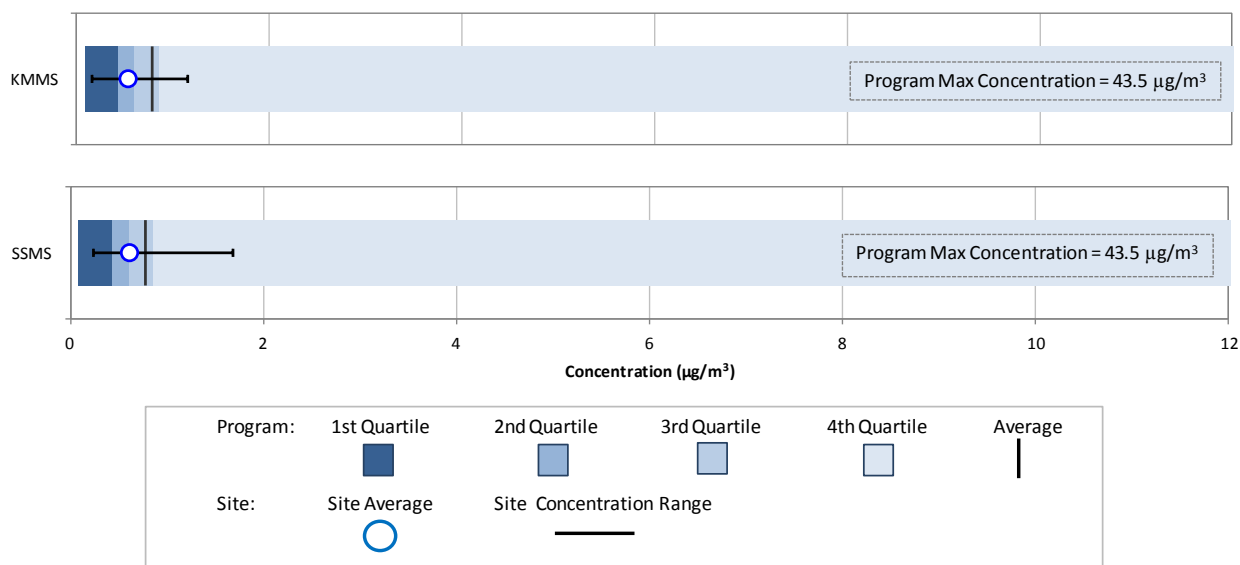


Figure 18-7. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

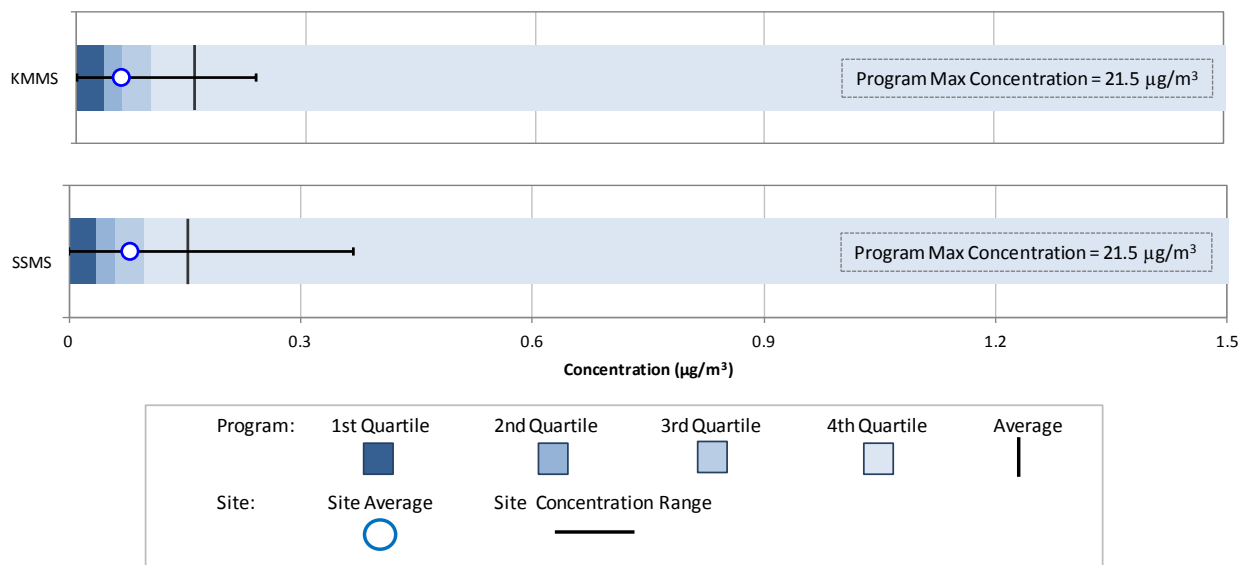


Figure 18-8. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations

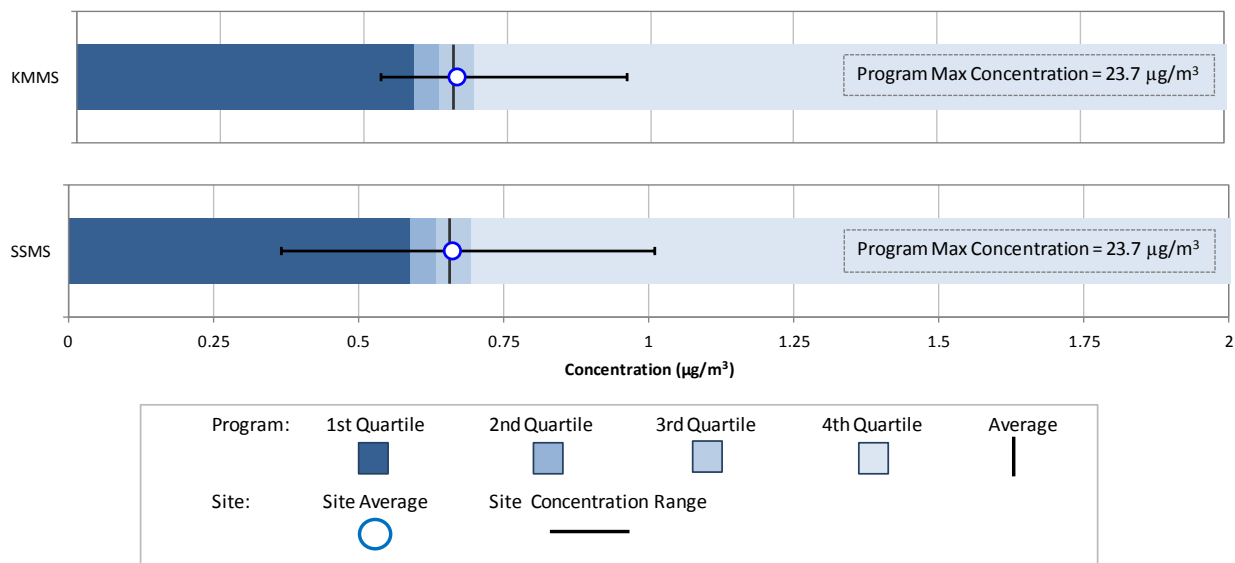


Figure 18-9. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentrations

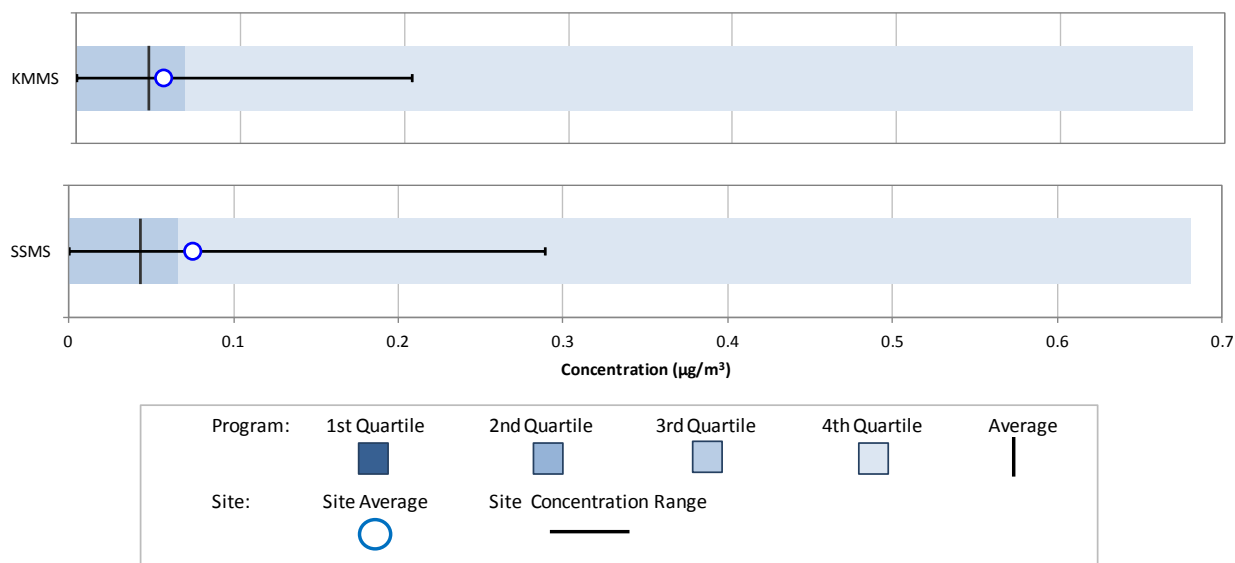


Figure 18-10. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations

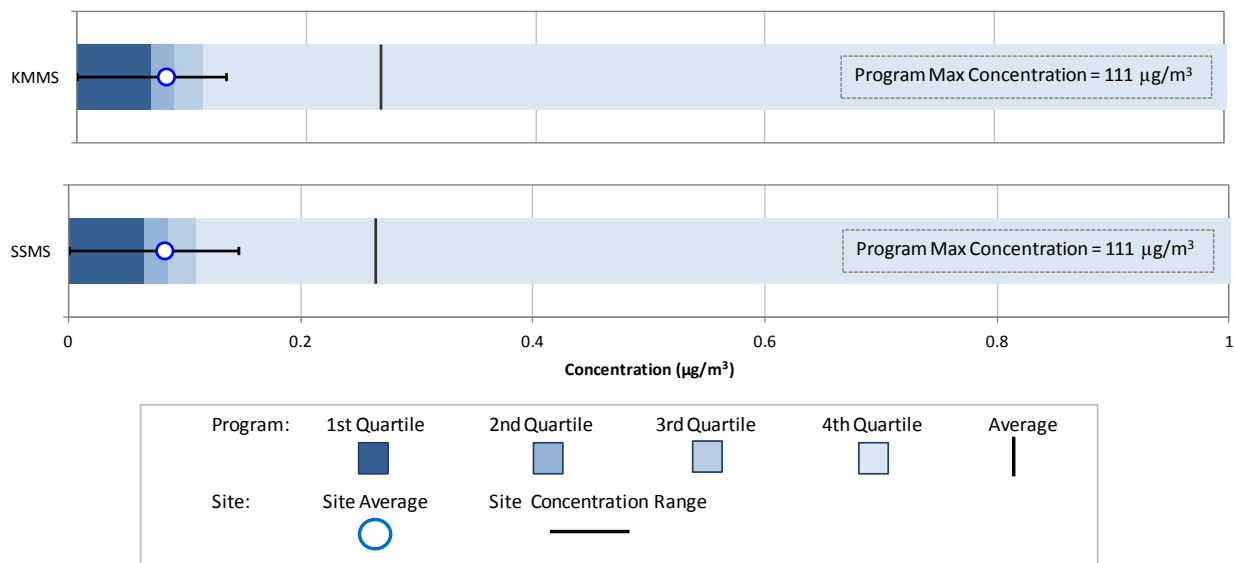


Figure 18-11. Program vs. Site-Specific Average Ethylbenzene Concentrations

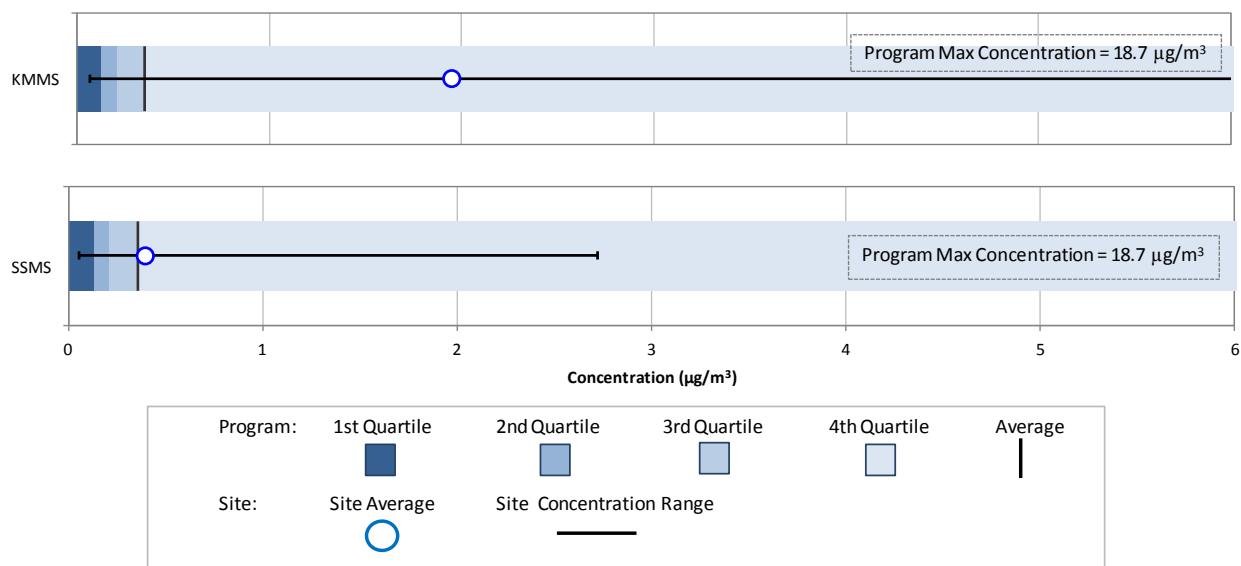


Figure 18-12. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentration

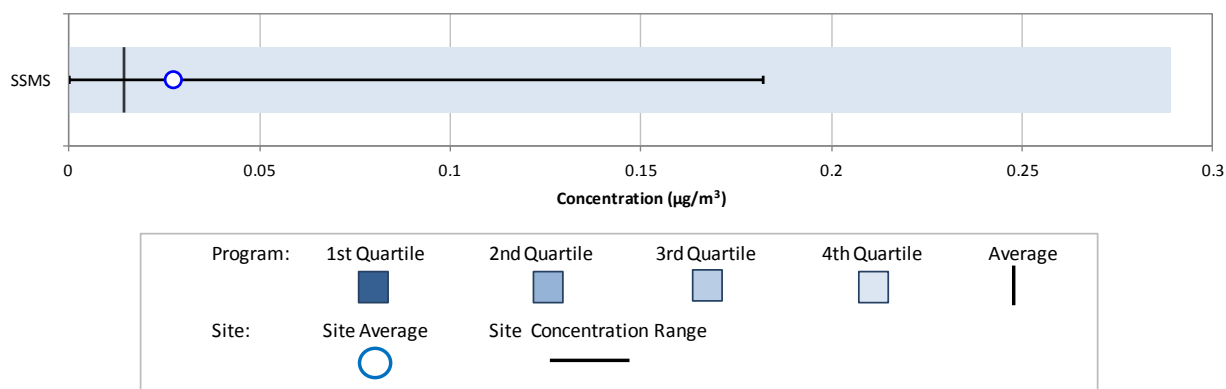
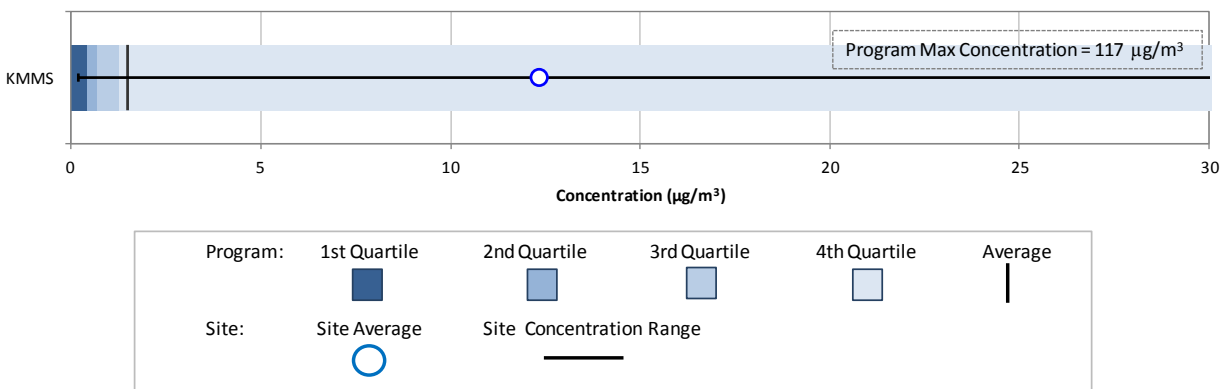


Figure 18-13. Program vs. Site-Specific Average Xylenes Concentration



Observations from Figures 18-6 through 18-13 include the following:

- Figure 18-6 presents the box plots for benzene for both sites. The program-level maximum benzene concentration ($43.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots as the scale has been reduced to $12 \mu\text{g}/\text{m}^3$ in Figure 18-6 to allow for the observation of data points at the lower end of the concentration range. The range of benzene concentrations measured at SSMS is greater than those measured at KMMS, although the entire range of benzene concentrations measured at both sites is less than $2 \mu\text{g}/\text{m}^3$. The annual average concentration for SSMS is slightly higher than the annual average concentration for KMMS, although both are less than the program-level average concentration.
- Figure 18-7 presents the box plots for 1,3-butadiene for both sites. Similar to benzene, the program-level maximum 1,3-butadiene concentration ($21.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots as the scale has been reduced to $1.5 \mu\text{g}/\text{m}^3$ in Figure 18-7 to allow for the observation of data points at the lower end of the concentration range. The range of 1,3-butadiene concentrations measured is larger for SSMS than KMMS, although all 1,3-butadiene concentrations measured at these sites are less than $0.4 \mu\text{g}/\text{m}^3$. The annual average concentration of 1,3-butadiene is slightly higher for SSMS than KMMS, although both are less than the program-level average concentration. However, the program-level average concentration is greater than the program-level third quartile, an indication that the measurements at the upper end of the concentration range are driving the program-level average.
- Figure 18-8 presents the box plots for carbon tetrachloride. The scale of these box plots has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum carbon tetrachloride concentration ($23.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. Figure 18-8 shows that the range of carbon tetrachloride concentrations measured at the Mississippi sites are considerably less than the range of concentrations measured across the program. Even though the range of concentrations measured at SSMS is larger than the range of concentrations measured at KMMS, the annual average carbon tetrachloride concentrations are

the same for both sites, and both are negligibly greater than the program-level average concentration.

- Figure 18-9 presents the box plots for *p*-dichlorobenzene for KMMS and SSMS. The program-level first and second (median) quartiles are both zero and therefore not visible on the box plots. This is due to the large number of non-detects of this pollutant across the program. Similar to several other VOCs, the range of concentrations measured was larger for SSMS than KMMS. The annual average concentration was slightly higher for SSMS than for KMMS, although both are greater than the program-level average concentration.
- The scale of the box plots in Figure 18-10 have also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum 1,2-dichloroethane concentration ($111 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. All of the concentrations of 1,2-dichloroethane measured at the Mississippi sites are less than the program-level average concentration of $0.26 \mu\text{g}/\text{m}^3$. The annual average concentrations for both Mississippi sites are just less than the program-level median concentration. This is another example of measurements at the upper end of the concentration range driving the program-level average concentration, as the program-level average is more than twice the program-level third quartile.
- Figure 18-11 presents the box plots for ethylbenzene for KMMS and SSMS. The scale of the box plots in Figure 18-11 have also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum ethylbenzene concentration ($18.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. The maximum concentration of ethylbenzene across the program was measured at KMMS and is more than six times greater than the maximum ethylbenzene concentration measured at SSMS. The annual average concentration for SSMS is just greater than the program-level average concentration while the annual average for KMMS is more than five times greater than the program-level average concentration.
- Figure 18-12 is the box plot for hexachloro-1,3-butadiene for SSMS (this pollutant is not a pollutant of interest for KMMS). The program-level first, second (median), and third quartiles are all zero and therefore not visible on the box plot. This is due to the large number of non-detects of this pollutant across the program (82 percent). Although the maximum hexachloro-1,3-butadiene concentration was not measured at SSMS, the second and third highest concentrations were. Recall from the previous section that this site has the highest annual average hexachloro-1,3-butadiene concentration among NMP sites sampling VOCs. The annual average concentration for SSMS is nearly twice the program-level average concentration. It should be noted, however, that none of the measured detections of hexachloro-1,3-butadiene across the program were greater than the MDL for this pollutant.

- Figure 18-13 is the box plot for xylenes for KMMS, the only NMP site for which this is a pollutant of interest. The scale of the box plot in Figure 18-13 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum xylenes concentration ($117 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. The maximum xylenes concentration measured across the program was measured at KMMS, and a second similar concentration was also measured at this site. The annual average xylenes concentration for KMMS is more than eight times greater than the program-level average concentration. This is another example of measurements at the upper end of the concentration range driving the program-level average concentration, as the program-level average concentration is greater than the program-level third quartile and more than twice the program-level median concentration.

18.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. Because the two Columbus, Mississippi sites are part of a 1-year monitoring effort completed at the end of the 2013, a trends analysis could not be conducted for these sites.

18.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at each Mississippi monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

18.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Mississippi monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 18-6, where applicable. Cancer risk approximations are

presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Observations for KMMS from Table 18-6 include the following:

- The pollutants of interest with the highest annual average concentrations for KMMS are xylenes, ethylbenzene, carbon tetrachloride, and benzene.
- Based on the annual averages and cancer UREs, ethylbenzene has the highest cancer risk approximation (4.87 in-a-million), followed by benzene (4.15 in-a-million), and carbon tetrachloride (3.98 in-a-million). Note that xylenes do not have a cancer URE.
- None of the pollutants of interest for KMMS have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation for KMMS is xylenes (0.12).

Observations for SSMS from Table 18-6 include the following:

- The pollutants with the highest annual average concentrations are carbon tetrachloride, benzene, and ethylbenzene, although none of these pollutants have an annual average concentration greater than $1 \mu\text{g}/\text{m}^3$.
- Based on the annual averages and cancer UREs, benzene has the highest cancer risk approximation for SSMS (4.71 in-a-million), followed by carbon tetrachloride (3.97 in-a-million), and 1,3-butadiene (2.37 in-a-million).
- None of the pollutants of interest for SSMS have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation for SSMS is 1,3-butadiene (0.04).

Table 18-6. Risk Approximations for the Mississippi Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Kerr-McGee, Columbus, Mississippi - KMMS						
Benzene	0.0000078	0.03	60/60	0.53 ± 0.06	4.15	0.02
1,3-Butadiene	0.00003	0.002	51/60	0.06 ± 0.01	1.74	0.03
Carbon Tetrachloride	0.000006	0.1	60/60	0.66 ± 0.02	3.98	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	39/60	0.05 ± 0.01	0.58	<0.01
1,2-Dichloroethane	0.000026	2.4	57/60	0.08 ± 0.01	2.02	<0.01
Ethylbenzene	0.0000025	1	60/60	1.95 ± 1.08	4.87	<0.01
Xylenes	--	0.1	60/60	12.33 ± 7.20	--	0.12
Acenaphthene ^a	0.000088	--	30/30	NA	NA	NA
Fluorene ^a	0.000088	--	30/30	NA	NA	NA
Naphthalene ^a	0.000034	0.003	30/30	NA	NA	NA
Stokes-Beard Elementary School, Columbus, Mississippi - SSMS						
Benzene	0.0000078	0.03	61/61	0.60 ± 0.07	4.71	0.02
1,3-Butadiene	0.00003	0.002	58/61	0.08 ± 0.02	2.37	0.04
Carbon Tetrachloride	0.000006	0.1	61/61	0.66 ± 0.02	3.97	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	48/61	0.08 ± 0.02	0.83	<0.01
1,2-Dichloroethane	0.000026	2.4	58/61	0.08 ± 0.01	2.15	<0.01
Ethylbenzene	0.0000025	1	61/61	0.39 ± 0.12	0.98	<0.01
Hexachloro-1,3-butadiene	0.000022	0.09	19/61	0.03 ± 0.01	0.60	<0.01

-- = A Cancer URE or Noncancer RfC is not available.

NA = Not available due to the criteria for calculating an annual average.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

18.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 18-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 18-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 18-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 18-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 18-7. Table 18-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 18.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 18-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Mississippi Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Kerr-McGee, Columbus, Mississippi (Lowndes County) - KMMS					
Ethylbenzene	50.88	Formaldehyde	4.89E-04	Ethylbenzene	4.87
Acetaldehyde	47.06	Nickel, PM	3.75E-04	Benzene	4.15
Benzene	38.47	Benzene	3.00E-04	Carbon Tetrachloride	3.98
Formaldehyde	37.64	Naphthalene	2.68E-04	1,2-Dichloroethane	2.02
Naphthalene	7.88	Hexavalent Chromium	2.19E-04	1,3-Butadiene	1.74
1,3-Butadiene	5.07	Arsenic, PM	1.60E-04	p-Dichlorobenzene	0.58
Tetrachloroethylene	3.81	1,3-Butadiene	1.52E-04		
Dichloromethane	1.23	Ethylbenzene	1.27E-04		
Nickel, PM	0.78	Acetaldehyde	1.04E-04		
POM, Group 2b	0.46	POM, Group 2b	4.02E-05		
Stokes-Beard Elementary School, Columbus, Mississippi (Lowndes County) - SSMS					
Ethylbenzene	50.88	Formaldehyde	4.89E-04	Benzene	4.71
Acetaldehyde	47.06	Nickel, PM	3.75E-04	Carbon Tetrachloride	3.97
Benzene	38.47	Benzene	3.00E-04	1,3-Butadiene	2.37
Formaldehyde	37.64	Naphthalene	2.68E-04	1,2-Dichloroethane	2.15
Naphthalene	7.88	Hexavalent Chromium	2.19E-04	Ethylbenzene	0.98
1,3-Butadiene	5.07	Arsenic, PM	1.60E-04	p-Dichlorobenzene	0.83
Tetrachloroethylene	3.81	1,3-Butadiene	1.52E-04	Hexachloro-1,3-butadiene	0.60
Dichloromethane	1.23	Ethylbenzene	1.27E-04		
Nickel, PM	0.78	Acetaldehyde	1.04E-04		
POM, Group 2b	0.46	POM, Group 2b	4.02E-05		

Table 18-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Mississippi Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Kerr-McGee, Columbus, Mississippi (Lowndes County) - KMMS					
Methanol	881.01	Acrolein	113,667.50	Xylenes	0.12
Xylenes	231.91	Chlorine	66,619.28	1,3-Butadiene	0.03
Toluene	150.47	Manganese, PM	19,091.49	Benzene	0.02
Hexane	83.91	Nickel, PM	8,690.62	Carbon Tetrachloride	0.01
Ethylbenzene	50.88	Acetaldehyde	5,229.22	Ethylbenzene	<0.01
Acetaldehyde	47.06	Formaldehyde	3,840.61	p-Dichlorobenzene	<0.01
Hydrochloric acid	38.52	Naphthalene	2,627.71	1,2-Dichloroethane	<0.01
Benzene	38.47	1,3-Butadiene	2,533.29		
Formaldehyde	37.64	Arsenic, PM	2,474.52		
Methyl isobutyl ketone	16.64	Xylenes	2,319.10		
Stokes-Beard Elementary School, Columbus, Mississippi (Lowndes County) - SSMS					
Methanol	881.01	Acrolein	113,667.50	1,3-Butadiene	0.04
Xylenes	231.91	Chlorine	66,619.28	Benzene	0.02
Toluene	150.47	Manganese, PM	19,091.49	Carbon Tetrachloride	0.01
Hexane	83.91	Nickel, PM	8,690.62	Ethylbenzene	<0.01
Ethylbenzene	50.88	Acetaldehyde	5,229.22	Hexachloro-1,3-butadiene	<0.01
Acetaldehyde	47.06	Formaldehyde	3,840.61	p-Dichlorobenzene	<0.01
Hydrochloric acid	38.52	Naphthalene	2,627.71	1,2-Dichloroethane	<0.01
Benzene	38.47	1,3-Butadiene	2,533.29		
Formaldehyde	37.64	Arsenic, PM	2,474.52		
Methyl isobutyl ketone	16.64	Xylenes	2,319.10		

Observations from Table 18-7 include the following:

- Ethylbenzene is the highest emitted pollutants with a cancer URE in Lowndes County, followed by acetaldehyde and benzene. Although the quantity of emissions is not very high, this is the only county with an NMP site for which ethylbenzene ranks highest for quantity emitted.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, nickel, and benzene.
- Eight of the highest emitted pollutants in Lowndes County also have the highest toxicity-weighted emissions.
- Ethylbenzene has the highest cancer risk approximation for KMMS, which ranks highest for total emissions and eighth highest for toxicity-weighted emissions. Benzene and 1,3-butadiene also appear among the pollutants with the highest cancer risk approximations and on both emissions-based lists. The remaining pollutants of interest for KMMS appear on neither emissions-based list. Similar observations can be made for SSMS.
- Naphthalene is the fifth highest emitted pollutant in Lowndes County and ranks fourth for its toxicity-weighted emissions. Naphthalene was sampled for at KMMS and was identified as a pollutant of interest, but PAHs were not long enough for an annual average concentration, and thus, risk approximations, to be calculated. POM, Group 2b ranks 10th highest for both its total emissions and its toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at KMMS, including acenaphthene and fluorene, both of which were also identified as pollutants of interest for KMMS.
- Several metals and carbonyl compounds appear among the highest emitted pollutants in Lowndes County and have some of the highest toxicity-weighted emissions. Speciated metals and carbonyl compounds were not sampled for at KMMS or SSMS as part of this monitoring effort.

Observations from Table 18-8 include the following:

- Methanol, xylenes, and toluene are the highest emitted pollutants with noncancer RfCs in Lowndes County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, chlorine, and manganese.
- Three of the highest emitted pollutants also have the highest toxicity-weighted emissions for Lowndes County.
- Acrolein has the highest toxicity-weighted emissions for Lowndes County. Although acrolein was sampled for at both sites, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to

questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- Xylenes have the highest noncancer hazard approximation for KMMS, followed by 1,3-butadiene and benzene. 1,3-Butadiene and benzene have the highest noncancer hazard approximations for SSMS (xylenes were not identified as a pollutant of interest for SSMS). However, all noncancer hazard approximations calculated for the Mississippi sites are considerably less than an HQ of 1.0 (all are less than 0.15).
- Of the pollutants of interest for KMMS and SSMS, xylenes, benzene, and ethylbenzene appear among the highest emitted pollutants in Lowndes County while only xylenes and 1,3-butadiene appear among those with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs).
- Several metals and carbonyl compounds appear among the highest emitted pollutants in Lowndes County and have some of the highest toxicity-weighted emissions. Speciated metals and carbonyl compounds were not sampled at KMMS or SSMS as part of this monitoring effort.

18.6 Summary of the 2013 Monitoring Data for KMMS and SSMS

Results from several of the data treatments described in this section include the following:

- ❖ *Fourteen pollutants failed screens for KMMS; 10 pollutants failed screens for SSMS.*
- ❖ *Of the site-specific pollutants of interest for KMMS, xylenes had the highest annual average concentration. KMMS is the only pollutant for which xylenes was identified as a pollutant of interest, with several of the highest concentrations of this pollutant across the program measured at this site. For SSMS, carbon tetrachloride had the highest annual average concentration among this site's pollutants of interest.*
- ❖ *Compared to other sites sampling VOCs, KMMS has the highest annual average concentration of ethylbenzene, with several of the highest concentrations of this pollutant across the program measured at this site. SSMS has the highest annual average concentration of hexachloro-1,3-butadiene among NMP sites sampling VOCs.*
- ❖ *Ethylbenzene has the highest cancer risk approximation of the pollutants of interest for KMMS while benzene has the highest cancer risk approximation of the pollutants of interest for SSMS. None of the pollutants of interest for the Mississippi sites have noncancer hazard approximations greater than an HQ of 1.0.*

19.0 Site in Missouri

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Missouri, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

19.1 Site Characterization

This section characterizes the S4MO monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The S4MO monitoring site is located in the St. Louis, MO-IL CBSA. Figure 19-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 19-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 19-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 19-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 19-1. St. Louis, Missouri (S4MO) Monitoring Site

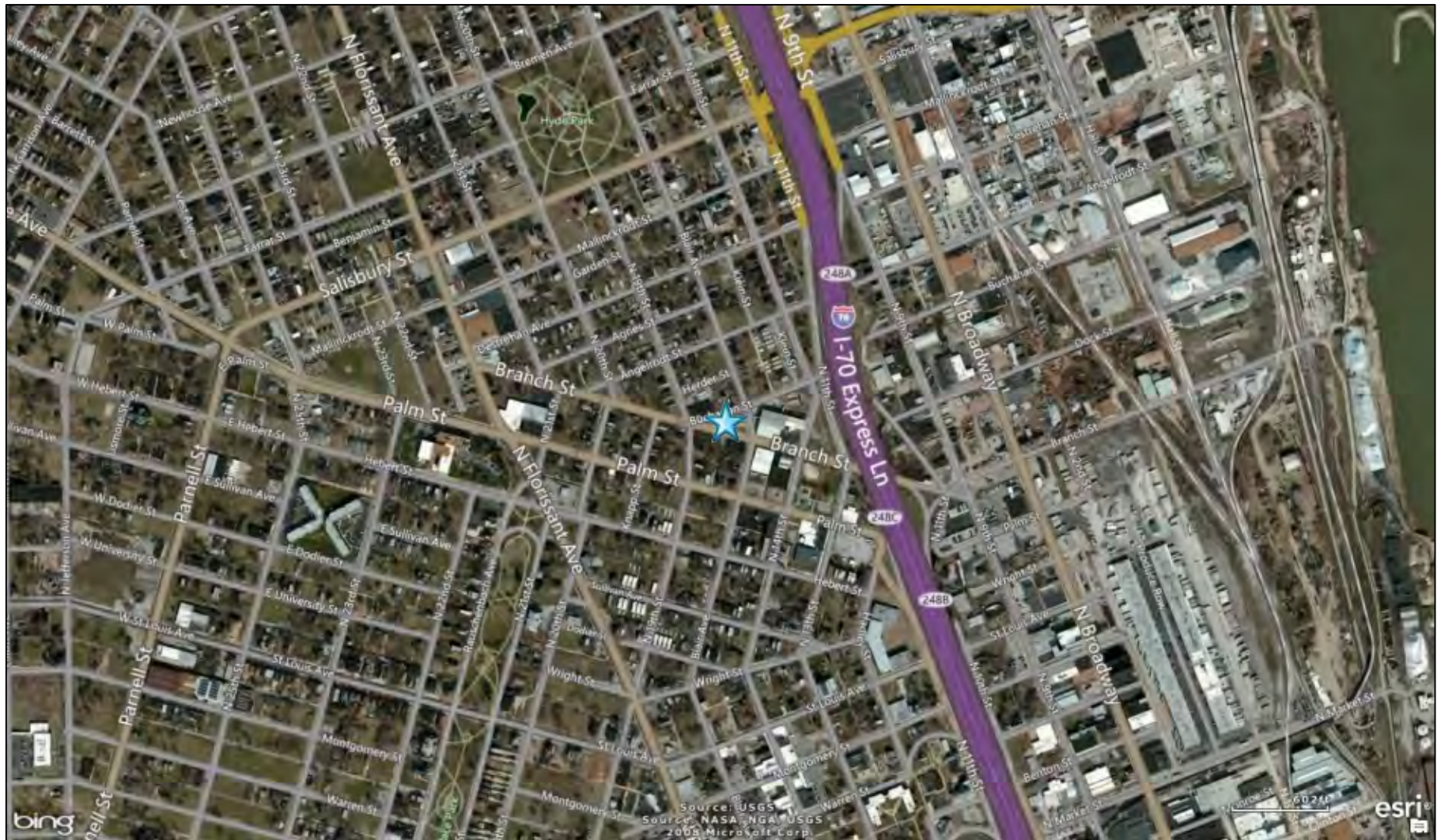


Figure 19-2. NEI Point Sources Located Within 10 Miles of S4MO

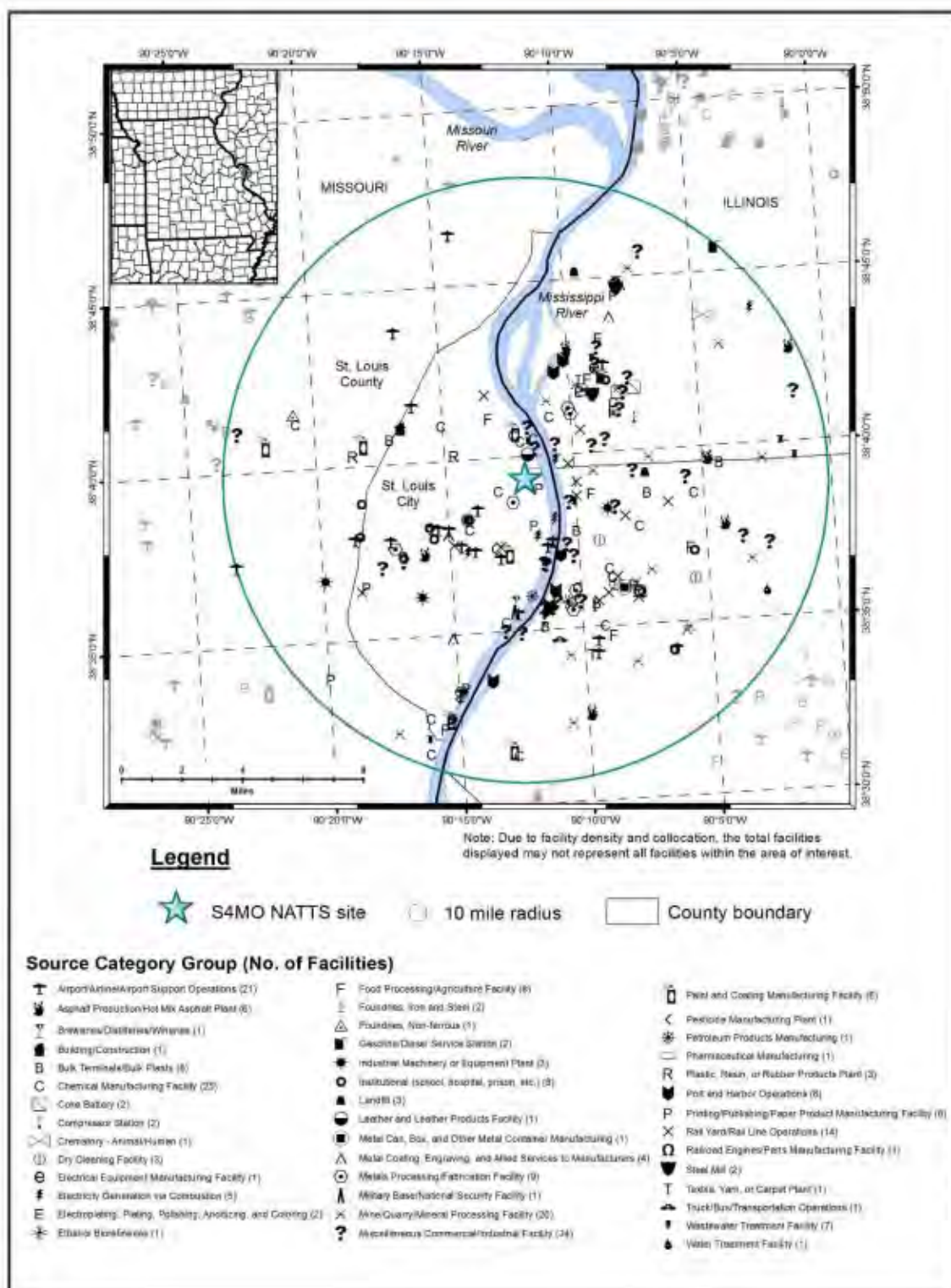


Table 19-1. Geographical Information for the Missouri Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>S4MO</i>	29-510-0085	St. Louis	St. Louis City	St. Louis, MO-IL	38.656449, -90.198548	Residential	Urban/City Center	TSP Lead, CO, SO ₂ , NO ₂ , NO _x , NO _y , NO, O ₃ , Meteorological parameters, PM ₁₀ , PM Coarse, Black carbon, PM _{2.5} , PM _{2.5} Speciation, SO ₂ , IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for this site (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

S4MO is located in central St. Louis. Figure 19-1 shows that the S4MO monitoring site is located less than one-quarter mile west of I-70. The Mississippi River, which separates Missouri and Illinois, is less than 1 mile east of the site. Although the area directly around the monitoring site is primarily residential, industrial facilities are located nearby, primarily just on the other side of I-70. Figure 19-2 shows that a large number of point sources are located within 10 miles of S4MO, particularly on the east side of the Missouri/Illinois border. The source categories with the greatest number of point sources surrounding S4MO include chemical manufacturing facilities; airport and airport support operations, which include airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; mines, quarries, and mineral processing facilities; and rail yard/rail line operations. Within 1 mile of S4MO are a pharmaceutical manufacturing facility, a printing and publishing facility, a leather products facility, a metals processing/fabrication facility, and a chemical manufacturing facility.

Table 19-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Missouri monitoring site. Table 19-2 includes both county-level population and vehicle registration information. Table 19-2 also contains traffic volume information for S4MO as well as the location for which the traffic volume was obtained. Additionally, Table 19-2 presents the county-level daily VMT for S4MO. Note that because the state of Missouri provides data within the city of St. Louis separately from St. Louis County, Table 19-2 includes the combination of the city and county data for county-level statistics in order to compare these statistics with other NMP sites' county-level data.

Table 19-2. Population, Motor Vehicle, and Traffic Information for the Missouri Monitoring Site

Site	County	Estimated County Population¹	County-level Vehicle Registration²	Annual Average Daily Traffic³	Intersection Used for Traffic Data	County-level Daily VMT⁴
<i>S4MO</i>	St. Louis City + County	1,319,860	1,117,375	100,179	I-70 at I-44 split (at bridge)	24,065,245

¹County-level population estimate reflects county and city data for 2013 (Census Bureau, 2014)

²County-level vehicle registration reflects county and city data for 2013 (MO DOR, 2014)

³AADT reflects 2013 data (MO DOT, 2013)

⁴County-level VMT reflects county and city data for 2013 (MO DOT, 2014)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 19-2 include the following:

- S4MO's county-level population and vehicle registration rank 11th and 12th highest, respectively, compared to other counties with NMP sites.
- The traffic volume experienced near S4MO ranks 14th, which falls in the upper third of the range compared to other NMP sites. The traffic estimate provided is for I-70 near the split with I-44 (at the bridge).
- The VMT for S4MO is roughly 24 million miles, ranking 13th among counties with NMP sites.

19.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Missouri on sample days, as well as over the course of the year.

19.2.1 Climate Summary

The city of St. Louis is located along the Mississippi River, which is Missouri's eastern border. St. Louis has a climate that is continental in nature, with cold, dry winters; warm, muggy summers; and significant seasonal variability. Warm, moist air flowing northward from the Gulf of Mexico alternates with cold, dry air moving southward from Canada and the northern U.S., resulting in weather patterns that are relatively short in duration. Southerly winds prevail during the warmer months of the year, while west-northwesterly winds prevail the rest of the year. Thunderstorms are common, particularly in the spring, summer, and fall, and annual snowfall totals average around 20 inches. The city of St. Louis experiences the urban heat island effect, retaining more heat within the city than outlying areas (Wood, 2004 and MCC, 2015).

19.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Missouri monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station to S4MO is located at St. Louis Downtown Airport (WBAN 03960). Additional information about this weather station, such as the distance between the site and the weather station, is provided in Table 19-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 19-3. Average Meteorological Conditions near the Missouri Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction From Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
St. Louis, Missouri - S4MO									
St. Louis Downtown Airport 03960 (38.57, -90.16)	6.3 miles 159° (SSE)	Sample Days (62)	62.5 ± 5.5	53.4 ± 5.2	43.1 ± 5.2	48.3 ± 4.8	70.5 ± 2.6	1018.5 ± 1.9	5.4 ± 0.6
		2013	64.8 ± 2.1	54.8 ± 1.9	43.8 ± 1.9	49.3 ± 1.8	69.2 ± 1.1	1017.9 ± 0.7	5.6 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

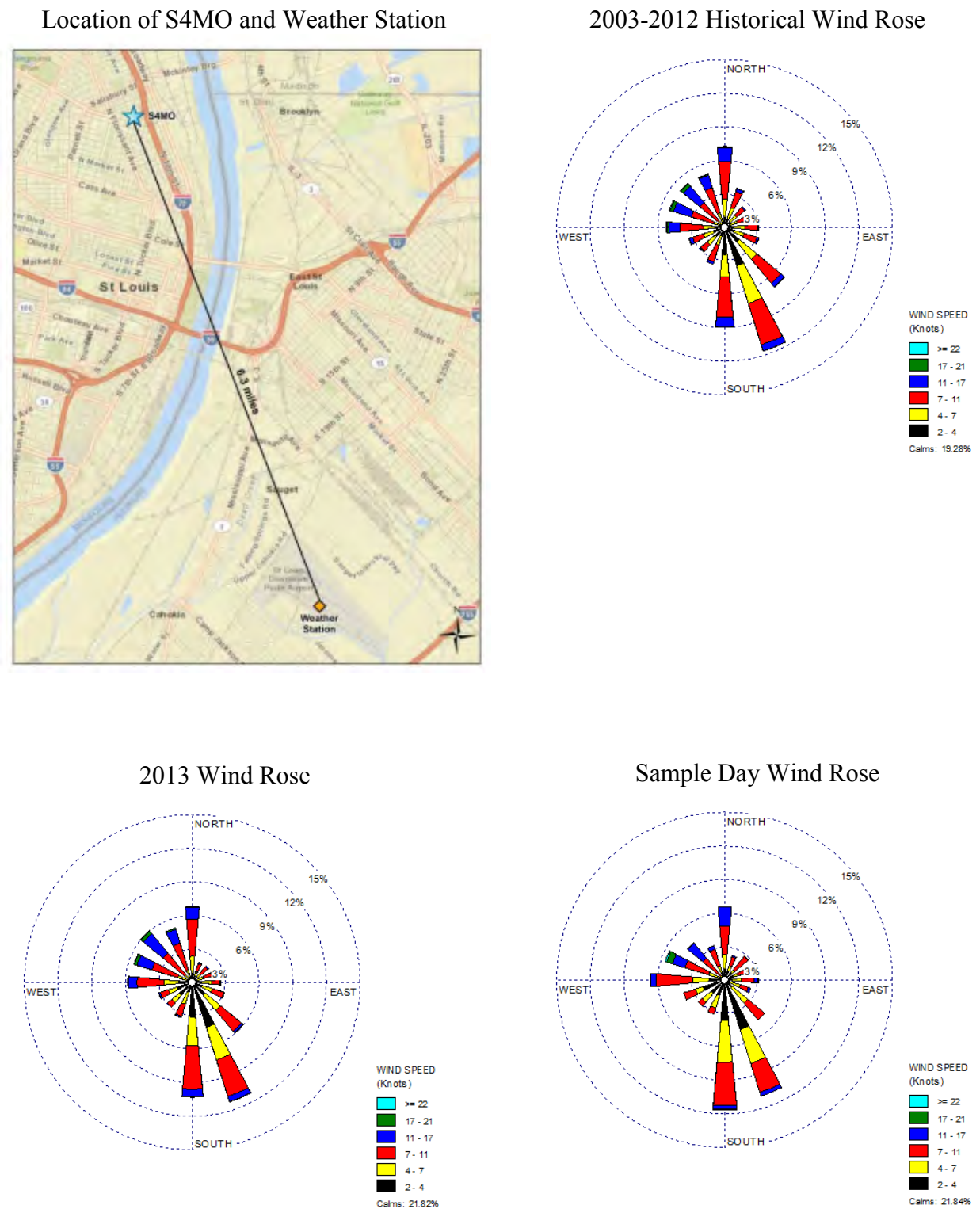
Table 19-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 19-3 is the 95 percent confidence interval for each parameter. Although average meteorological conditions on sample days are not statistically different than the average meteorological conditions experienced throughout 2013, the temperatures appear slightly cooler on sample days, as shown in Table 19-3. Few of the hottest days in 2013 were sample days at S4MO.

19.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at St. Louis Downtown Airport near S4MO were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 19-3 presents a map showing the distance between the weather station and S4MO, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 19-3 also presents three different wind roses for the S4MO monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 19-3. Wind Roses for the St. Louis Downtown Airport Weather Station near S4MO



Observations from Figure 19-3 for S4MO include the following:

- The St. Louis Downtown Airport weather station is located approximately 6 miles south-southeast of S4MO. The weather station location is across the Mississippi River and state border in Cahokia, Illinois.
- The historical wind rose shows that winds from the southeast, south-southeast, and south were frequently observed near S4MO, with prevailing winds from the south-southeast. Winds from these directions account for approximately 28 percent of observations. Calm winds (those less than or equal to 2 knots) were observed for approximately 19 percent of the hourly wind measurements. Winds from the west to northwest to north account for the majority of the remaining wind observations. The strongest winds were from the west to northwest.
- The wind patterns shown on the 2013 wind rose generally resemble those shown on the historical wind rose, although the percentage of calm winds was slightly higher in 2013 (22 percent).
- The wind patterns on the sample day wind rose mostly resemble the historical and full-year wind roses, although there are a few differences. Fewer winds from the southeast, northwest, and north-northwest were observed while winds from the south were observed more frequently.

19.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the S4MO monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 19-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 19-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. VOCs, PAHs, carbonyl compounds, metals (PM₁₀), and hexavalent chromium were sampled for at S4MO. S4MO is one of two NATTS sites that sampled hexavalent chromium year-round.

Table 19-4. Risk-Based Screening Results for the Missouri Monitoring Site

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
St. Louis, Missouri - S4MO						
Acetaldehyde	0.45	61	61	100.00	10.63	10.63
Benzene	0.13	61	61	100.00	10.63	21.25
Carbon Tetrachloride	0.17	61	61	100.00	10.63	31.88
Formaldehyde	0.077	61	61	100.00	10.63	42.51
Arsenic (PM ₁₀)	0.00023	60	61	98.36	10.45	52.96
1,2-Dichloroethane	0.038	58	58	100.00	10.10	63.07
1,3-Butadiene	0.03	56	57	98.25	9.76	72.82
Naphthalene	0.029	54	60	90.00	9.41	82.23
<i>p</i> -Dichlorobenzene	0.091	21	47	44.68	3.66	85.89
Cadmium (PM ₁₀)	0.00056	20	61	32.79	3.48	89.37
Hexachloro-1,3-butadiene	0.045	16	17	94.12	2.79	92.16
Lead (PM ₁₀)	0.015	12	61	19.67	2.09	94.25
Acenaphthene	0.011	7	60	11.67	1.22	95.47
Fluorene	0.011	7	60	11.67	1.22	96.69
Nickel (PM ₁₀)	0.0021	7	61	11.48	1.22	97.91
Ethylbenzene	0.4	3	61	4.92	0.52	98.43
Manganese (PM ₁₀)	0.03	3	61	4.92	0.52	98.95
Propionaldehyde	0.8	3	61	4.92	0.52	99.48
Acenaphthylene	0.011	1	36	2.78	0.17	99.65
Benzo(a)pyrene	0.00057	1	57	1.75	0.17	99.83
1,2-Dibromoethane	0.0017	1	1	100.00	0.17	100.00
Total		574	1124	51.07		

Observations from Table 19-4 include the following:

- Twenty-one pollutants failed at least one screen for S4MO; 51 percent of concentrations for these 21 pollutants were greater than their associated risk screening value (or failed screens). S4MO tied with BTUT for the highest number of individual pollutants failing screens.
- Fifteen pollutants contributed to 95 percent of failed screens for S4MO and therefore were identified as pollutants of interest for this site. These 15 include two carbonyl compounds, six VOCs, four PM₁₀ metals, and three PAHs. Although the 95 percent criteria is met with acenaphthene, fluorene and nickel are also considered pollutants of interest because they failed the same number of screens as acenaphthene, per the steps described in Section 3.2.
- S4MO has the greatest number of pollutants of interest among NMP sites. Similar to previous years, S4MO failed the highest number of screens (574) among all NMP sites (refer to Table 4-8 of Section 4.2). However, the failure rate for S4MO, when

incorporating all pollutants with screening values, is approximately 21 percent. This is due primarily to the relatively large number of pollutants sampled for at this site, as discussed in Section 4.2.

- Acetaldehyde, formaldehyde, benzene, carbon tetrachloride, and 1,2-dichloroethane failed 100 percent of screens for S4MO and were detected in all or most of the samples collected. 1,2-Dibromoethane also failed 100 percent of screens but was detected only once.
- Lead and cadmium were identified as pollutants of interest for only two NMP sites sampling metals: S4MO and ASKY-M.

19.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Missouri monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual average concentrations are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at S4MO are provided in Appendices J, L, M, N, and O.

19.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Missouri site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year

of sampling. Annual averages were calculated for pollutants where at least three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for S4MO are presented in Table 19-5, where applicable. Note that concentrations of the PAHs and metals are presented in ng/m³ for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 19-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Missouri Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
St. Louis, Missouri - S4MO						
Acetaldehyde	61/61	1.21 ± 0.16	2.01 ± 0.49	2.73 ± 0.37	1.96 ± 0.32	1.98 ± 0.22
Benzene	61/61	0.78 ± 0.08	0.50 ± 0.09	0.56 ± 0.08	0.59 ± 0.11	0.61 ± 0.05
1,3-Butadiene	57/61	0.06 ± 0.02	0.05 ± 0.02	0.06 ± 0.01	0.08 ± 0.02	0.07 ± 0.01
Carbon Tetrachloride	61/61	0.64 ± 0.05	0.69 ± 0.04	0.67 ± 0.04	0.56 ± 0.06	0.64 ± 0.03
<i>p</i> -Dichlorobenzene	47/61	0.06 ± 0.06	0.09 ± 0.04	0.12 ± 0.05	0.10 ± 0.04	0.09 ± 0.02
1,2-Dichloroethane	58/61	0.10 ± 0.01	0.11 ± 0.02	0.06 ± 0.02	0.09 ± 0.01	0.09 ± 0.01
Formaldehyde	61/61	1.65 ± 0.29	3.40 ± 1.02	5.73 ± 1.24	2.22 ± 0.31	3.23 ± 0.55
Hexachloro-1,3-butadiene	17/61	0.01 ± 0.02	0.02 ± 0.02	0.01 ± 0.02	0.05 ± 0.03	0.02 ± 0.01
Acenaphthene ^a	60/60	2.64 ± 1.25	5.45 ± 1.83	9.68 ± 2.68	2.32 ± 1.31	5.02 ± 1.16
Arsenic (PM ₁₀) ^a	61/61	0.65 ± 0.13	0.75 ± 0.13	1.01 ± 0.16	0.53 ± 0.14	0.73 ± 0.08
Cadmium (PM ₁₀) ^a	61/61	0.33 ± 0.15	0.56 ± 0.36	0.75 ± 0.52	0.60 ± 0.33	0.56 ± 0.18
Fluorene ^a	60/60	3.50 ± 1.00	6.34 ± 1.69	10.50 ± 2.27	2.80 ± 0.80	5.79 ± 1.07
Lead (PM ₁₀) ^a	61/61	7.12 ± 2.18	8.96 ± 3.93	14.13 ± 5.99	7.53 ± 3.00	9.40 ± 2.01
Naphthalene ^a	60/60	73.68 ± 24.15	61.16 ± 16.74	90.49 ± 23.65	62.34 ± 15.98	71.92 ± 10.08
Nickel (PM ₁₀) ^a	61/61	1.07 ± 0.45	1.24 ± 0.58	1.36 ± 0.78	0.61 ± 0.15	1.06 ± 0.26

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m³ for ease of viewing.

Observations for S4MO from Table 19-5 include the following:

- The pollutants with the highest annual average concentrations are formaldehyde ($3.23 \pm 0.55 \mu\text{g}/\text{m}^3$) and acetaldehyde ($1.98 \pm 0.22 \mu\text{g}/\text{m}^3$). These are the only pollutants of interest with annual averages greater than $1 \mu\text{g}/\text{m}^3$.
- The second and third quarter average concentrations of formaldehyde are significantly higher than the first and fourth quarter averages and have larger confidence intervals. Concentrations of formaldehyde measured at S4MO range from $0.90 \mu\text{g}/\text{m}^3$ to $9.86 \mu\text{g}/\text{m}^3$. The 19 highest concentrations were measured between May and September, or the warmest months of the year, with six measured during the second quarter and 13 measured during the third quarter. Conversely, 11 of the 13 formaldehyde concentrations less than $1.50 \mu\text{g}/\text{m}^3$ were measured during the first or fourth quarters and four of the five lowest concentrations were measured during the months of February and March.
- Concentrations of acetaldehyde were markedly less during the first quarter of 2013. Concentrations of acetaldehyde range from $0.711 \mu\text{g}/\text{m}^3$ to $3.88 \mu\text{g}/\text{m}^3$, with a median concentration $1.75 \mu\text{g}/\text{m}^3$. None of the concentrations measured during the first quarter were greater than the median concentration.
- Concentrations of benzene appear highest during the first quarter while concentrations measured during the fourth quarter have a higher level of variability. A review of the data shows that the maximum benzene concentration ($1.01 \mu\text{g}/\text{m}^3$) was measured at S4MO in November, while the next five highest concentrations were all measured between January and March. Two of the three lowest benzene concentrations were also measured during the fourth quarter of 2013.
- The third quarter average concentration of *p*-dichlorobenzene is twice the magnitude of the first quarter average, although the confidence interval is largest for the first quarter average. A review of the data shows that concentrations of *p*-dichlorobenzene measured at S4MO range from $0.0301 \mu\text{g}/\text{m}^3$ to $0.458 \mu\text{g}/\text{m}^3$ and include 14 non-detects. The maximum *p*-dichlorobenzene concentration was measured at S4MO in January and is the seventh highest *p*-dichlorobenzene concentration measured across the program. Only one of the 19 *p*-dichlorobenzene concentrations greater than $0.1 \mu\text{g}/\text{m}^3$ was measured during the first quarter (compared to five or more for each of the remaining calendar quarters). In addition, half of the 14 non-detects were measured during the first quarter, while no more than three were measured during the remaining calendar quarters.
- Concentrations of 1,2-dichloroethane appear higher during the first half of the year. Of the 21 concentrations of 1,2-dichloroethane greater than $0.1 \mu\text{g}/\text{m}^3$ measured at S4MO, 16 were measured during the first and second quarters of 2013, including every sample day in April. By comparison, only one concentration greater than $0.1 \mu\text{g}/\text{m}^3$ was measured during the third quarter and four were measured during the fourth quarter.

- The fourth quarter average concentration of hexachloro-1,3-butadiene is greater than the other quarterly averages. This pollutant was detected in roughly one-quarter of the samples collected, with nearly half of the measured detections measured during the fourth quarter. In addition, four of the five hexachloro-1,3-butadiene concentrations greater than $0.1 \mu\text{g}/\text{m}^3$ were measured in November and December, including the maximum concentration ($0.171 \mu\text{g}/\text{m}^3$), which is the fourth highest hexachloro-1,3-butadiene concentration measured across the program.
- Lead has the highest annual average concentration ($9.40 \pm 2.01 \text{ ng}/\text{m}^3$) among the PM_{10} metals identified as pollutants of interest for S4MO, followed by nickel ($1.06 \pm 0.26 \text{ ng}/\text{m}^3$).
- The confidence intervals associated with the quarterly average concentrations of lead are relatively large, indicating that there is a high level of variability in the measurements. Concentrations of lead measured at S4MO range from $1.31 \text{ ng}/\text{m}^3$ to $49.9 \text{ ng}/\text{m}^3$. The maximum concentration measured at S4MO is the highest concentration of lead measured among all NMP sites sampling metals and four of the seven concentrations greater than $20 \text{ ng}/\text{m}^3$ across the program were measured at S4MO (of which three of the four were measured in July and August).
- The quarterly averages of cadmium and nickel also reflect a high level of variability, particularly the third quarter, based on the associated confidence intervals. Concentrations of cadmium measured at S4MO span two orders of magnitude, ranging from $0.055 \text{ ng}/\text{m}^3$ to $4.08 \text{ ng}/\text{m}^3$. The maximum concentration of cadmium measured at S4MO is the third highest cadmium concentration measured across the program and more than one-third of the 21 cadmium concentrations greater than $1 \text{ ng}/\text{m}^3$ measured across the program were measured at S4MO (eight), the most of any NMP site.
- Concentrations of nickel measured at S4MO range from $0.188 \text{ ng}/\text{m}^3$ to $6.37 \text{ ng}/\text{m}^3$. The maximum concentration of nickel measured at S4MO is among the highest nickel concentrations measured across the program. The fourth quarter average concentration of nickel is considerably less than the other quarterly averages and has a considerably smaller confidence interval. The fourth quarter includes the fewest number of nickel concentrations greater than $1 \text{ ng}/\text{m}^3$ (one), compared to the other quarterly averages, which include between five and six each. Conversely, the fourth quarter includes the largest number of nickel concentrations less than $1 \text{ ng}/\text{m}^3$ (15), compared to the other quarterly averages, which include between nine and 10 each.
- Concentrations of arsenic appear highest during the third quarter of 2013 at S4MO. A review of the data shows that arsenic concentrations measured at S4MO range from $0.055 \text{ ng}/\text{m}^3$ to $1.47 \text{ ng}/\text{m}^3$. The three highest concentrations were all measured during the third quarter and of the 13 arsenic concentrations greater than $1 \text{ ng}/\text{m}^3$ measured at S4MO, eight were measured between July and September.
- Naphthalene has the highest annual average concentration among the PAHs identified as pollutants of interest for S4MO. The highest concentrations were measured during the third quarter at S4MO, although the confidence interval calculated for the first

quarter average is larger than the confidence interval for the third quarter. Concentrations of naphthalene measured at S4MO range from 10.1 ng/m³ to 182 ng/m³. Although six of the 11 naphthalene concentrations greater than 100 ng/m³ measured at S4MO were measured during the third quarter, three others were measured during the first three sample days of 2013 (January 4th, 10th, and 16th), including the two highest concentrations. Conversely, two of the four lowest concentrations were also measured during the first quarter of 2013.

- Concentrations of acenaphthene and fluorene appear to be highest during the warmer months of the year, particularly the third quarter, although each of the quarterly averages exhibit a considerable level of variability associated with them. A review of the data shows that the maximum concentration of each pollutant was measured on July 15, 2012 (20.2 ng/m³ and 18.2 ng/m³, respectively). Of the eight concentrations of acenaphthene greater than 10 ng/m³, all but two were measured between July and September (with the other two in April and May). Conversely, all but two of the 20 acenaphthene concentrations less than 2 ng/m³ were measured during the first or fourth quarters of 2013 (eight during the first quarter and 10 during the fourth). For fluorene, the highest 16 concentrations were measured at S4MO during the second or third quarters of 2013, with 11 measured between July and September. Conversely, all nine of the fluorene measurements less than 2.0 ng/m³ were measured in either the first or fourth quarter of the year.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for S4MO from those tables include the following:

- S4MO appears in Tables 4-9 through 4-12 a total of eight times, which ties with PXSS for the most of any NMP site.
- S4MO has the second highest annual average concentration of hexachloro-1,3-butadiene, the fourth highest annual average concentration of *p*-dichlorobenzene, and the eighth highest annual average concentration of 1,2-dichloroethane, as shown in Table 4-9.
- S4MO appears in Table 4-10 for both formaldehyde and acetaldehyde, ranking eighth and ninth, respectively, among NMP sites sampling carbonyl compounds.
- S4MO's annual average concentration of acenaphthene ranks sixth highest among NMP sites sampling PAHs, while this site's annual average concentration of naphthalene does not rank among the top 10.
- S4MO has the fifth highest annual average concentration of arsenic and the seventh highest annual average concentration of nickel among NMP sites sampling PM₁₀ metals.

19.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 19-4 for S4MO. Figures 19-4 through 19-18 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 19-4. Program vs. Site-Specific Average Acenaphthene Concentration

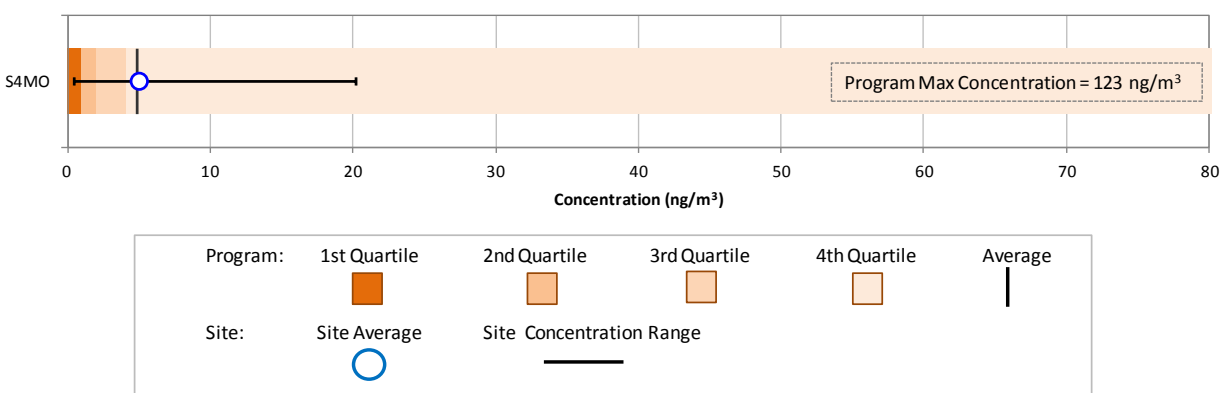


Figure 19-5. Program vs. Site-Specific Average Acetaldehyde Concentration

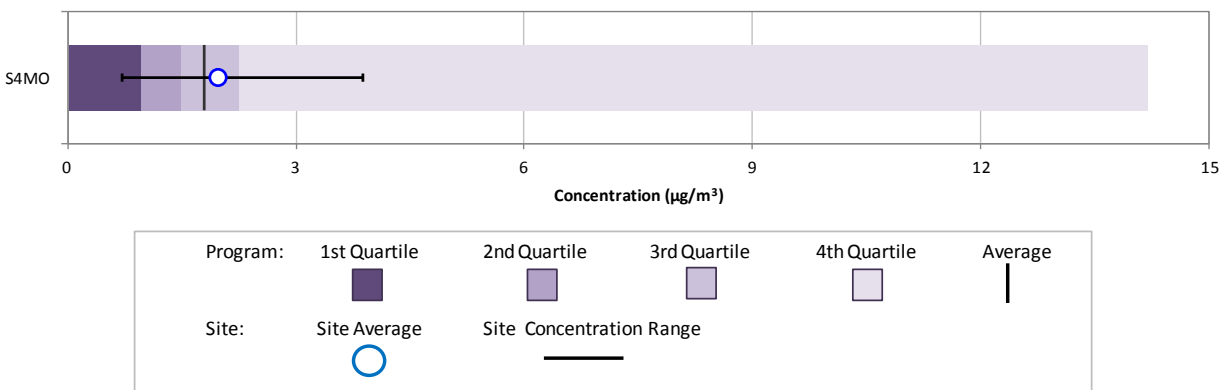


Figure 19-6. Program vs. Site-Specific Average Arsenic (PM₁₀) Concentration

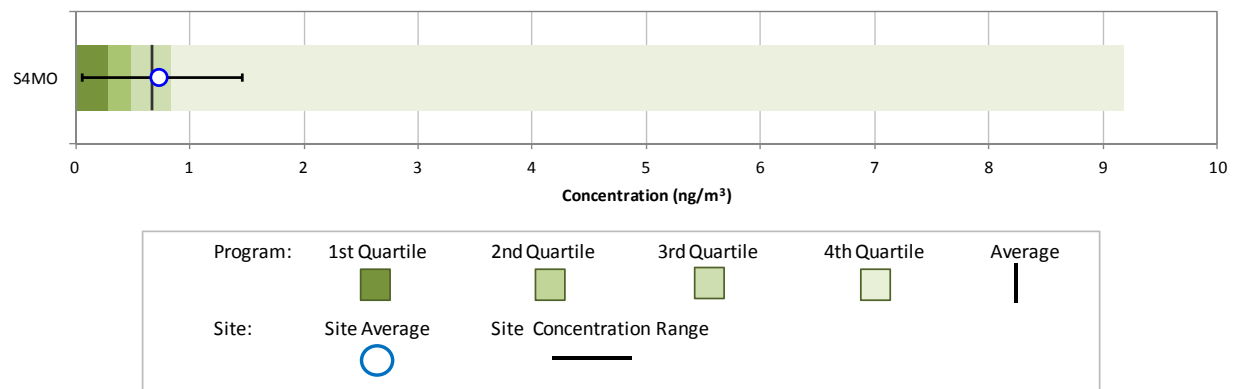


Figure 19-7. Program vs. Site-Specific Average Benzene Concentration

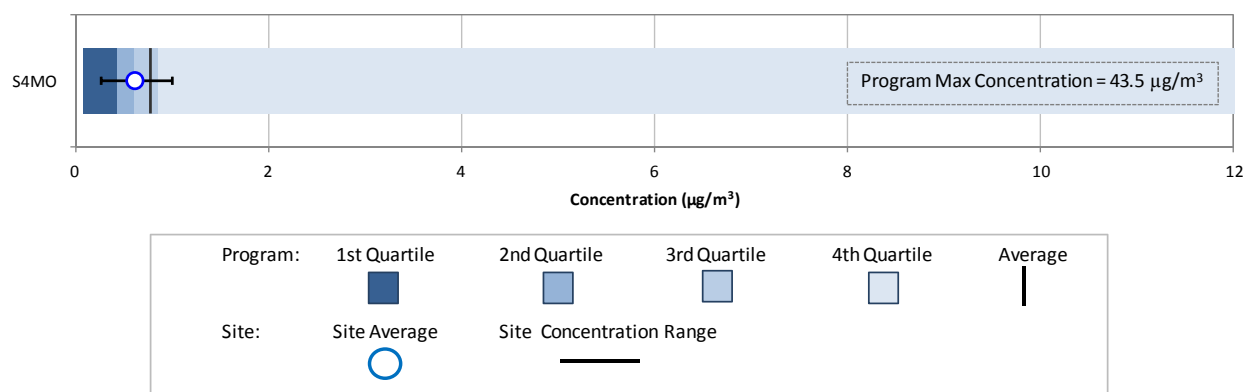


Figure 19-8. Program vs. Site-Specific Average 1,3-Butadiene Concentration

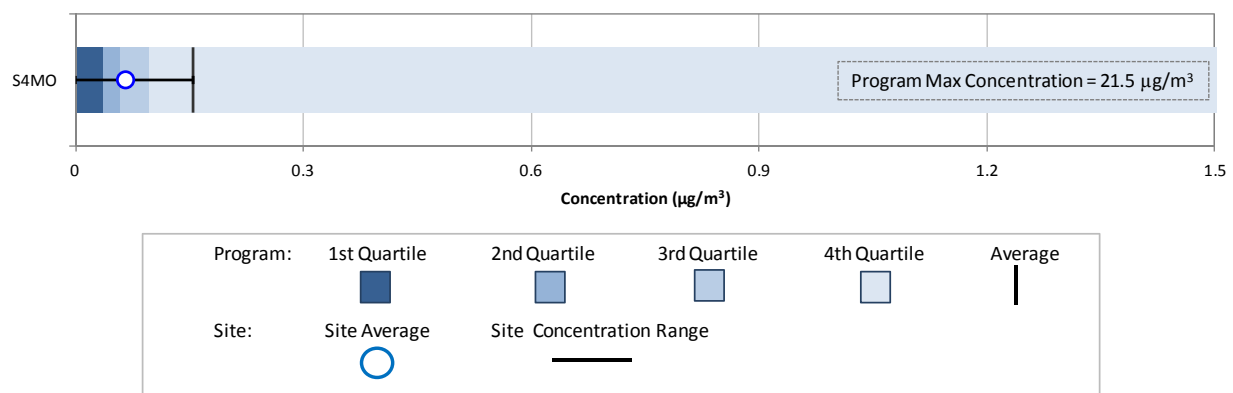


Figure 19-9. Program vs. Site-Specific Average Cadmium (PM₁₀) Concentration

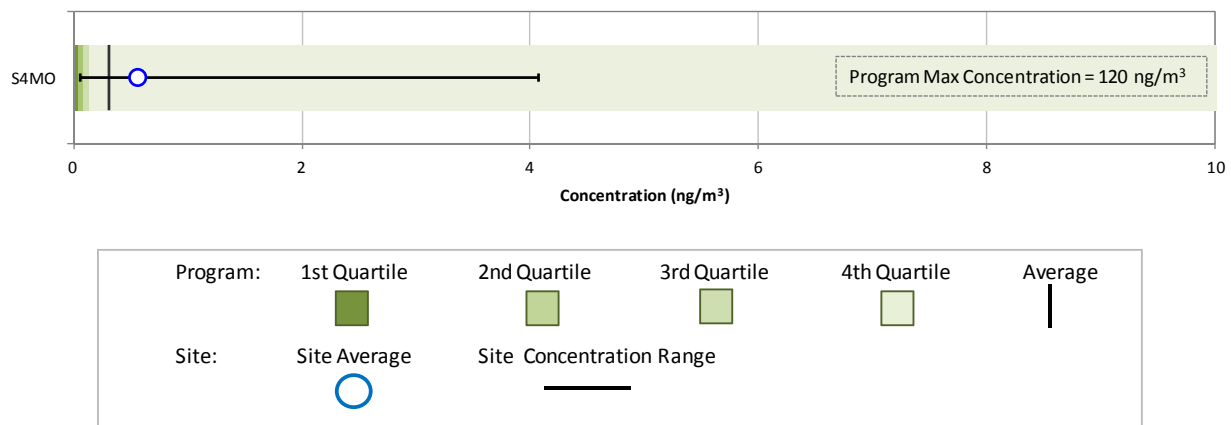


Figure 19-10. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

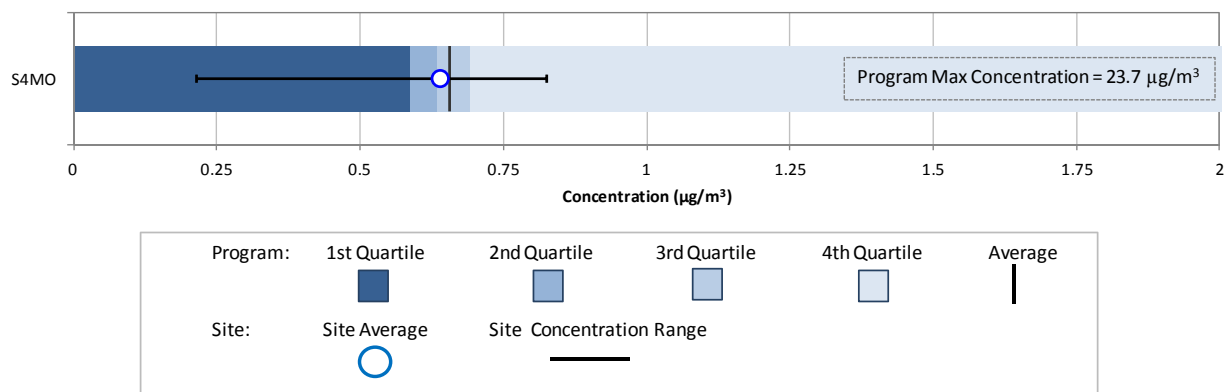


Figure 19-11. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentration

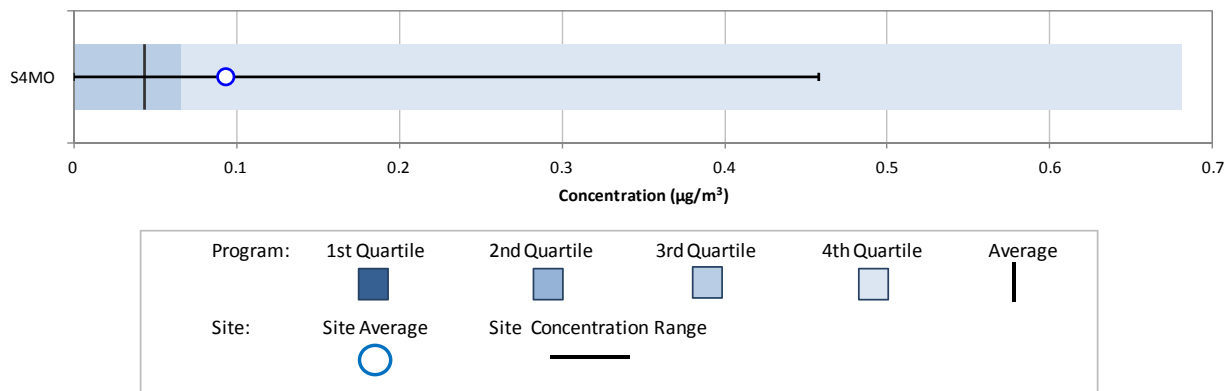


Figure 19-12. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

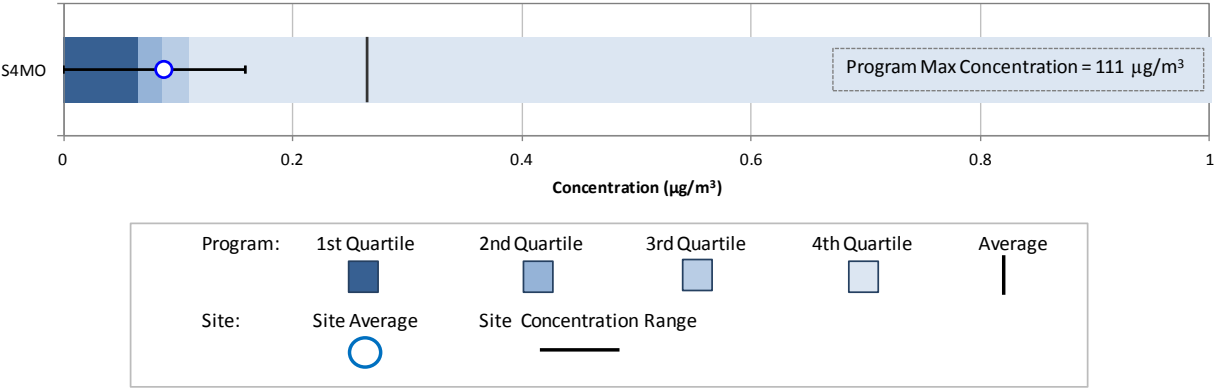


Figure 19-13. Program vs. Site-Specific Average Fluorene Concentration

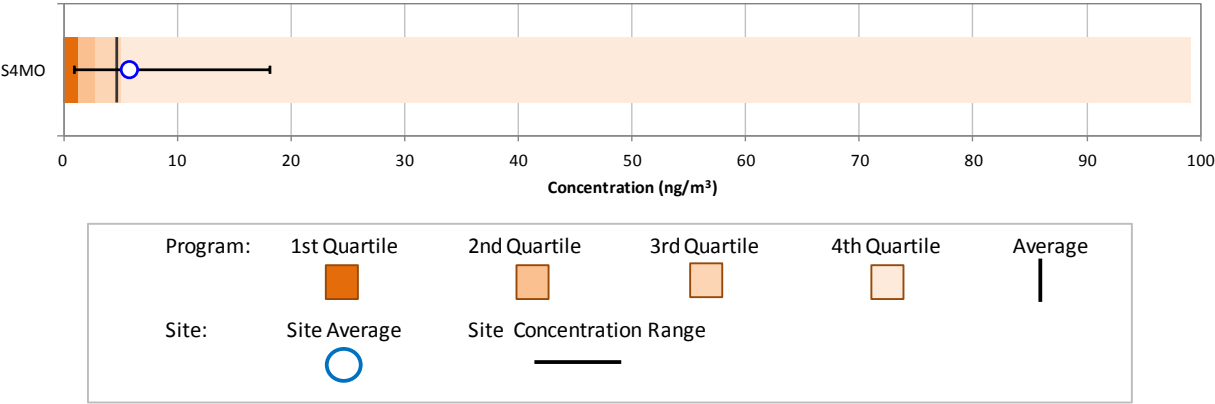


Figure 19-14. Program vs. Site-Specific Average Formaldehyde Concentration

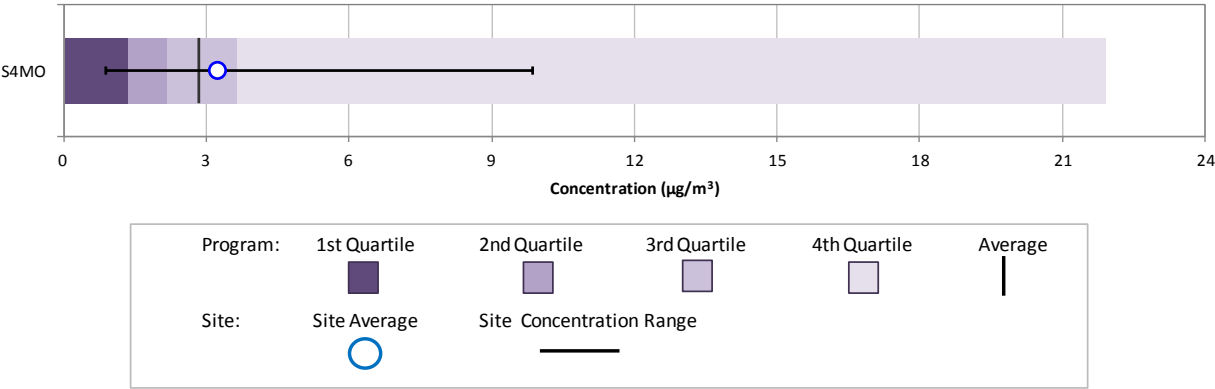


Figure 19-15. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentration

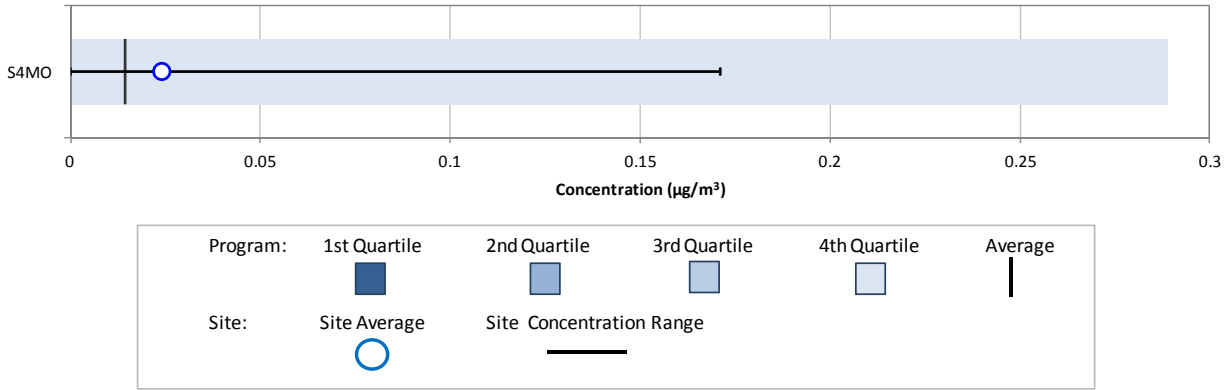


Figure 19-16. Program vs. Site-Specific Average Lead (PM₁₀) Concentration

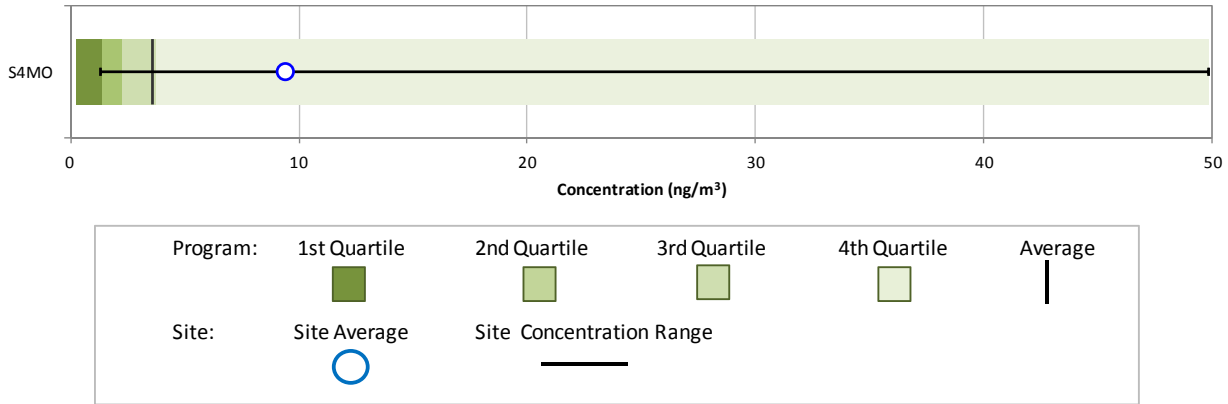


Figure 19-17. Program vs. Site-Specific Average Naphthalene Concentration

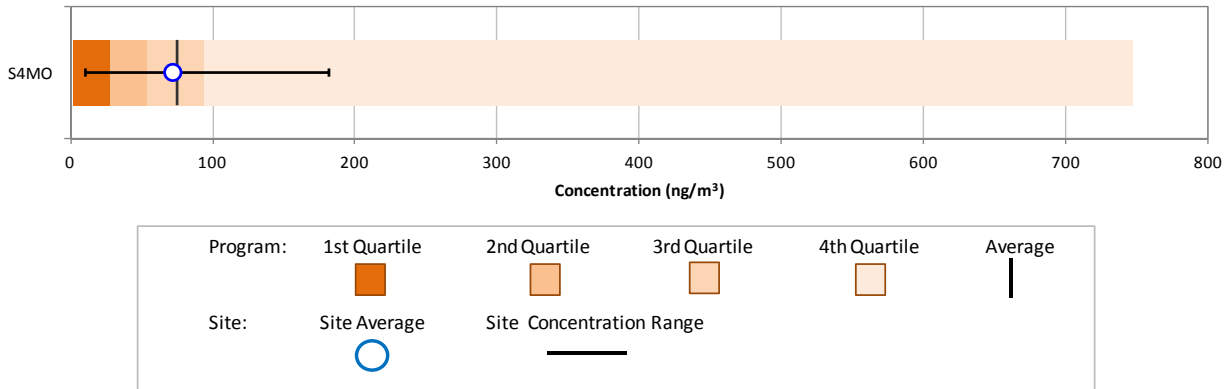
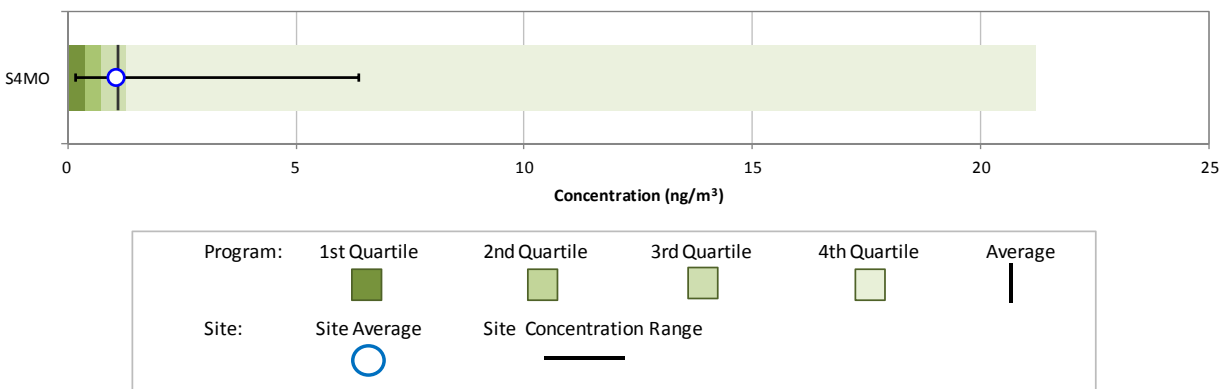


Figure 19-18. Program vs. Site-Specific Average Nickel (PM₁₀) Concentration



Observations from Figures 19-4 through 19-18 include the following:

- Figure 19-4 is the box plot for acenaphthene. Note that the program-level maximum concentration (123 ng/m³) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 80 ng/m³. Figure 19-4 shows that the maximum acenaphthene concentration measured at S4MO is considerably less than the maximum concentration measured at the program-level. Yet, the annual average concentration of acenaphthene for S4MO is similar to the program-level average concentration. Although a few non-detects of acenaphthene were measured across the program, none were measured at S4MO.
- Figure 19-5 shows that the annual average acetaldehyde concentration for S4MO is just greater than the program-level average concentration. The maximum acetaldehyde concentration measured at S4MO is considerably less than the maximum concentration measured across the program. The minimum concentration measured at S4MO is among the higher minimum concentrations among NMP sites sampling this pollutant.
- Figure 19-6 shows that the maximum arsenic (PM₁₀) concentration measured at S4MO is about one-sixth the maximum concentration measured across the program. S4MO's annual average arsenic (PM₁₀) concentration falls between the program-level average concentration and third quartile. Recall from the previous section that this site has the fifth highest annual average arsenic concentration among NMP sites sampling PM₁₀ metals.
- Figure 19-7 is the box plot for benzene. Note that the program-level maximum concentration (43.5 µg/m³) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 12 µg/m³. This box plot shows that the range of benzene concentrations measured at S4MO is relatively small compared to the range measured at the program-level. In fact, the range of benzene concentrations for S4MO is the third smallest among NMP sites sampling benzene with Method TO-15. The annual average benzene

concentration for S4MO is less than the program-level average concentration and similar to the program-level median concentration.

- Similar to acenaphthene and benzene, the program-level maximum 1,3-butadiene concentration ($21.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot as the scale has been reduced to $1.5 \mu\text{g}/\text{m}^3$ in Figure 19-8 to allow for the observation of data points at the lower end of the concentration range. Figure 19-8 for 1,3-butadiene shows that the program-level average concentration is being driven by the highest concentrations measured at a few sites, as the program average is greater than the third quartile. The maximum concentration measured at S4MO is similar to the program-level average concentration. The annual average 1,3-butadiene concentration for S4MO is just greater than the program-level median concentration.
- The program-level maximum cadmium concentration ($120 \text{ ng}/\text{m}^3$) is not shown directly on the box plot in Figure 19-9 as the scale has been reduced to $10 \text{ ng}/\text{m}^3$ to allow for the observation of data points at the lower end of the concentration range. Even though Figure 19-9 shows that the maximum cadmium (PM_{10}) concentration measured at S4MO is considerably less than the maximum concentration measured across the program ($4.08 \text{ ng}/\text{m}^3$), it is the third highest cadmium concentration among NMP sites sampling PM_{10} metals. (Note that there is a considerable difference between the highest ($120 \text{ ng}/\text{m}^3$) and second highest ($5.05 \text{ ng}/\text{m}^3$) cadmium concentrations measured across the program). Of the 21 concentrations greater than $1 \text{ ng}/\text{m}^3$ measured across the program, eight were measured at S4MO. S4MO's annual average cadmium concentration is greater than the program-level average concentration and is the second highest annual average among NMP sites sampling PM_{10} metals. The minimum concentration measured at S4MO is greater than the program-level first quartile.
- The program-level maximum carbon tetrachloride concentration ($23.7 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot in Figure 19-10 as the scale has been reduced to $2 \mu\text{g}/\text{m}^3$ to allow for the observation of data points at the lower end of the concentration range. Figure 19-10 for carbon tetrachloride shows that the range of measurements collected at S4MO is relatively small compared to those measured at the program-level. The annual average concentration for S4MO falls between the program-level median and average concentrations, although only $0.02 \mu\text{g}/\text{m}^3$ separates these parameters.
- Figure 19-11 is the box plot for *p*-dichlorobenzene. Note that the first and second quartiles are zero and therefore not visible on the graph. Although the maximum *p*-dichloromethane concentration across the program was not measured at S4MO, the maximum concentration measured at S4MO is among the higher measurements. The annual average concentration of this pollutant for S4MO is more than twice the program-level average concentration. S4MO has the fourth highest annual average concentration of *p*-dichlorobenzene among NMP sites sampling this pollutant.

- Figure 19-12 is the box plot for 1,2-dichloroethane. The program-level maximum concentration ($111 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot as the scale has been reduced to $1 \mu\text{g}/\text{m}^3$ to allow for the observation of data points at the lower end of the concentration range. Figure 19-12 shows that the entire range of 1,2-dichloromethane measurements collected at S4MO is less than the program-level average concentration. The program-level average concentration is being driven by higher measurements collected at a handful of monitoring sites. The annual average concentration for S4MO is similar to the median concentration at the program level. Recall from the previous section that S4MO has the eighth highest annual average concentration among NMP sites sampling this pollutant.
- Figure 19-13 is the box plot for fluorene. The box plot shows that the majority of the fluorene measurements program-wide are within a relatively small concentration range as indicated by the first, second (median), and third quartiles, which are relatively close together. Seventy-five percent of the fluorene measurements program-wide are less than $5.03 \text{ ng}/\text{m}^3$. The maximum concentration measured across the program is significantly higher ($99.1 \text{ ng}/\text{m}^3$). The annual average concentration of fluorene for S4MO is greater than the program-level average and third quartile, although the maximum fluorene concentration measured at S4MO ($18.2 \text{ ng}/\text{m}^3$) is considerably less than the program-level maximum concentration.
- Figure 19-14 for formaldehyde shows that the maximum formaldehyde concentration measured at S4MO is roughly half the maximum concentration measured across the program. The annual average concentration for S4MO is greater than the program-level average concentration but less than the program-level third quartile and ranks eighth highest among NMP sites sampling formaldehyde.
- Figure 19-15 is the box plot for hexachloro-1,3-butadiene. Note that the first, second, and third quartiles for this pollutant are zero and thus, not visible on the box plot, due to the large number of non-detects. The box plot shows that the maximum concentration measured at S4MO is less than the program-level maximum concentration, although it is one of the higher measurements across the program. S4MO ranks second for the most measured detections of this pollutant (17). The annual average concentration of hexachloro-1,3-butadiene for S4MO is slightly greater than the program-level average concentration. Recall from the previous section that S4MO has the second highest annual average concentration among NMP sites sampling this pollutant, similar to 2012.
- Figure 19-16 shows that the majority of the lead measurements program-wide fall within a relatively small concentration range as indicated by the first, second (median), and third quartiles, which are relatively close together. The maximum lead concentration measured at S4MO is the maximum concentration measured across the program. The minimum lead concentration measured at S4MO ($1.31 \text{ ng}/\text{m}^3$) is just less than the program-level first quartile and is the only site-specific minimum lead concentration greater than $1 \text{ ng}/\text{m}^3$. The annual average lead (PM_{10}) concentration for S4MO is more than two and half times greater than

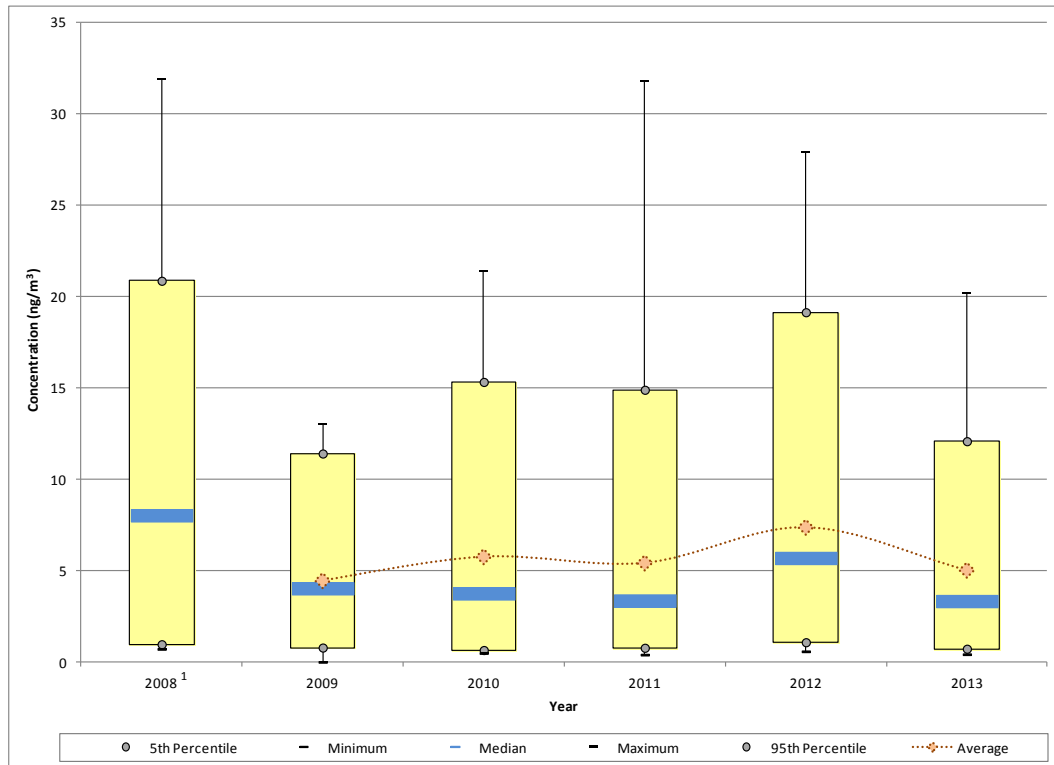
the program-level average concentration. This site has the highest annual average lead concentration among NMP sites sampling metals.

- Figure 19-17 is the box plot for naphthalene and shows that the maximum naphthalene concentration measured at S4MO is considerably less than the program-level maximum concentration. The annual average naphthalene concentration for S4MO is just less than the program-level average concentration.
- Figure 19-18 is the box plot for nickel. The maximum nickel concentration measured at S4MO is roughly one-third the program-level maximum concentration, although it is among the higher nickel concentrations measured across the program. S4MO's annual average nickel concentration is similar to the program-level average concentration.

19.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. S4MO has sampled VOCs and carbonyl compounds under the NMP since 2002, PM₁₀ metals since 2003, and PAHs since 2008. Thus, Figures 19-19 through 19-33 present the 1-year statistical metrics for each of the pollutants of interest for S4MO. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 19-19. Yearly Statistical Metrics for Acenaphthene Concentrations Measured at S4MO

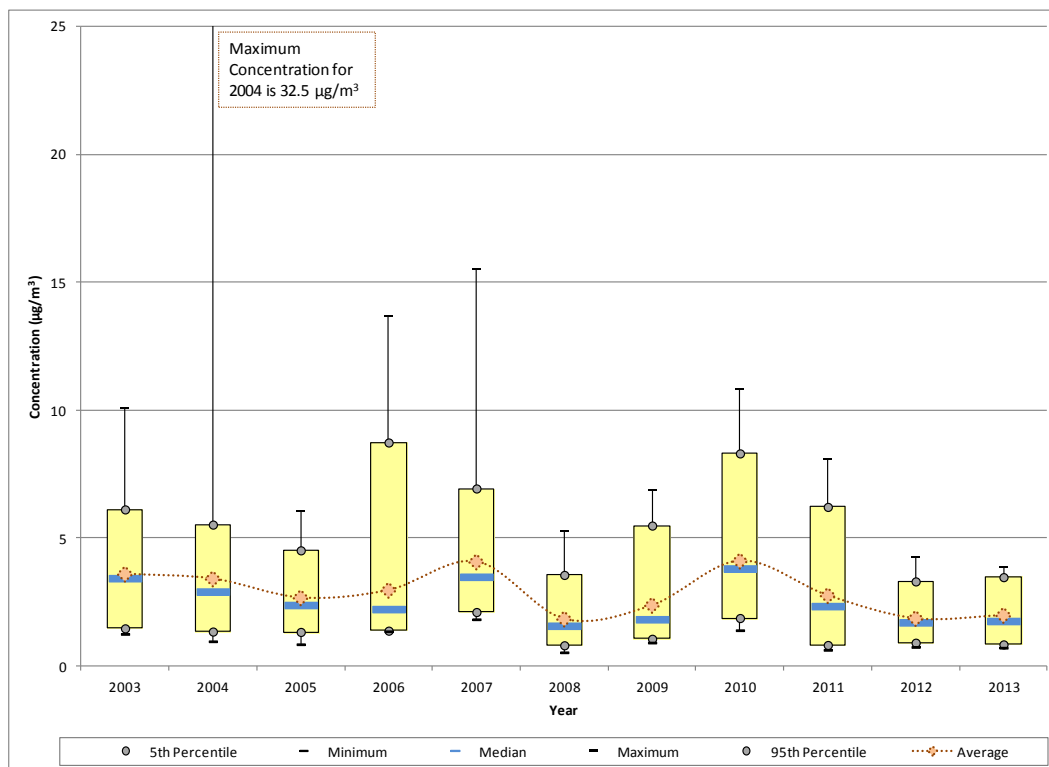


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 19-19 for acenaphthene measurements collected at S4MO include the following:

- S4MO began sampling PAHs under the NMP in April 2008. Because a full year's worth of data is not available, a 1-year average concentration for 2008 is not presented, although the range of measurements is provided.
- Two measurements greater than 30 ng/m³ were measured at S4MO in September 2008. Another measurement greater than 30 ng/m³ was also measured in July 2011.
- All of the statistical parameters shown exhibit decreases from 2008 to 2009. Although the range of concentrations measured increased from 2009 to 2010 and again for 2011, the median concentration decreased slightly each year.
- With the exception of the maximum concentration, the statistical parameters exhibit increases from 2011 to 2012. This is because the number of measurements at the upper end of the concentration range increased while the number of measurements at the lower end of the concentration decreased. The number of concentrations greater than 5 ng/m³ increased from 20 to 32 from 2011 to 2012 while the number of concentrations less than 1 ng/m³ decreased from 10 to three from 2011 to 2012.
- All of the statistical parameters exhibit decreases for 2013.

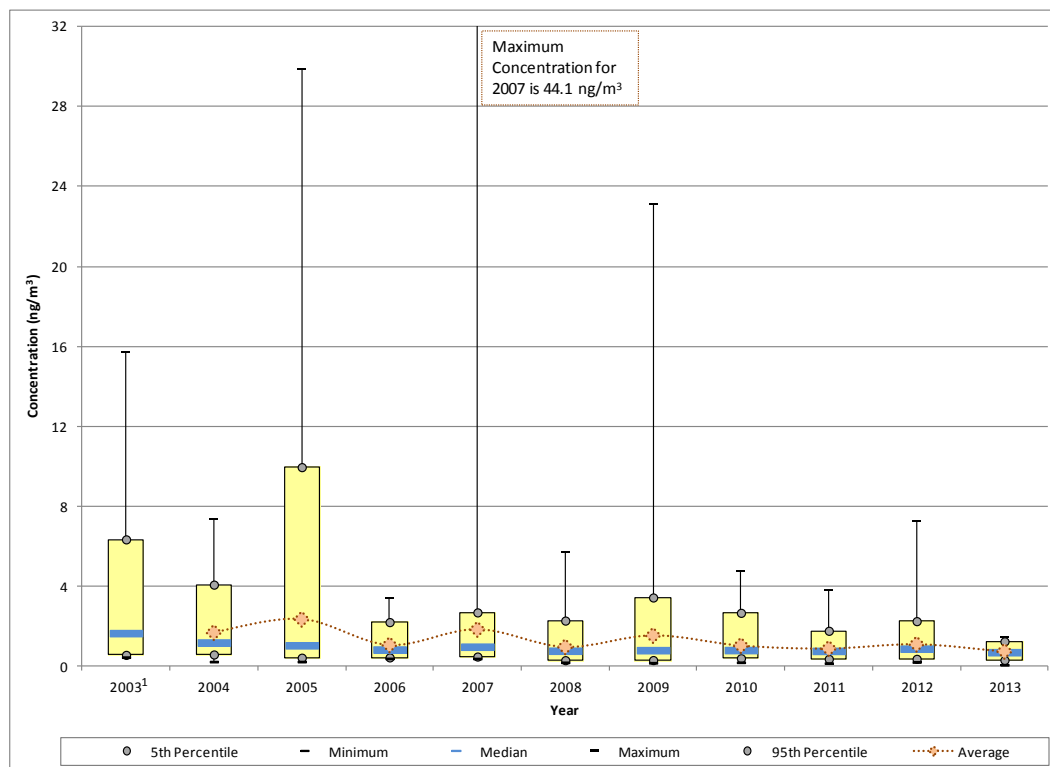
Figure 19-20. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at S4MO



Observations from Figure 19-20 for acetaldehyde measurements collected at S4MO include the following:

- Because carbonyl compound sampling under the NMP did not begin at S4MO until December 2002, data from 2002 were excluded from this analysis.
- The maximum acetaldehyde concentration was measured in 2004 ($32.5 \mu\text{g}/\text{m}^3$) and is more than twice the next highest concentration ($15.5 \mu\text{g}/\text{m}^3$, measured in 2007).
- Even with the maximum concentration measured in 2004, nearly all of the statistical metrics decreased from 2003 to 2004. The maximum concentration measured in 2004 is nearly six times higher than the next highest concentration measured that year ($5.72 \mu\text{g}/\text{m}^3$).
- The 1-year average concentrations have an undulating pattern, with a few years of a decreasing trend followed by a few years of an increasing trend. The 1-year average concentrations have ranged from $1.83 \mu\text{g}/\text{m}^3$ (2008) and $4.10 \mu\text{g}/\text{m}^3$ (2010).
- A significant decrease in the 1-year average concentration is shown from 2010 to 2011 and again for 2012, with little change for 2013. The range of concentrations measured is at a minimum for 2013 while the difference between the 5th and 95th percentiles, or the range within which 90 percent of the measurements fall, is at a minimum for 2012. The 2-year period from 2012 to 2013 exhibits the least year-to-year variability in concentrations measured since the onset of sampling.

Figure 19-21. Yearly Statistical Metrics for Arsenic (PM₁₀) Concentrations Measured at S4MO

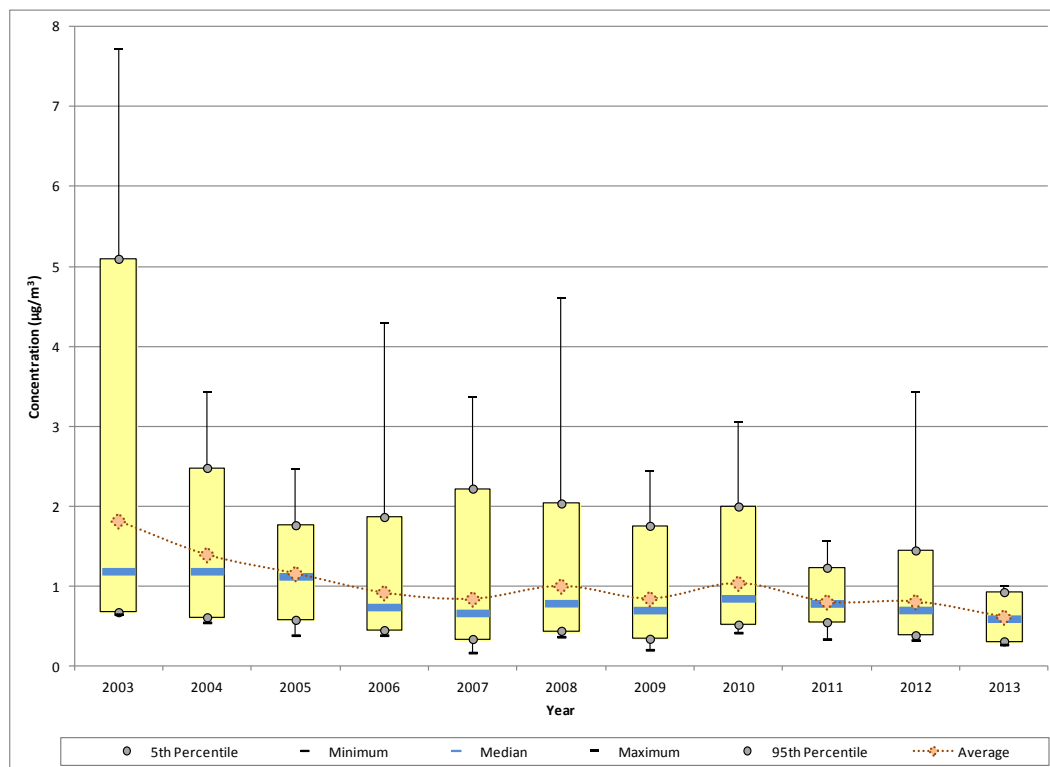


¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2003.

Observations from Figure 19-21 for arsenic measurements collected at S4MO include the following:

- S4MO began sampling metals under the NMP in July 2003. Because a full year's worth of data is not available, a 1-year average concentration is not presented, although the range of measurements is provided.
- The maximum arsenic concentration was measured at S4MO on December 26, 2007 (44.1 ng/m³). Five additional arsenic concentrations greater than 10 ng/m³ have been measured at S4MO (three in 2005 and one each in 2003, 2007, and 2009).
- This figure shows that years with little variability in the measurements seem to alternate with years with significant variability, particularly between 2004 and 2010. Less variability in the measurements is shown in the last few years of sampling.
- Most of the statistical parameters are at a minimum for 2013. The range of measurements, the difference between the 5th and 95th percentiles, and the difference between the median and 1-year average concentrations are all at a minimum for 2013 (less than 0.05 ng/m³ separates these two parameters, indicating a decrease in variability associated with the arsenic concentrations measured at S4MO in 2013).

Figure 19-22. Yearly Statistical Metrics for Benzene Concentrations Measured at S4MO

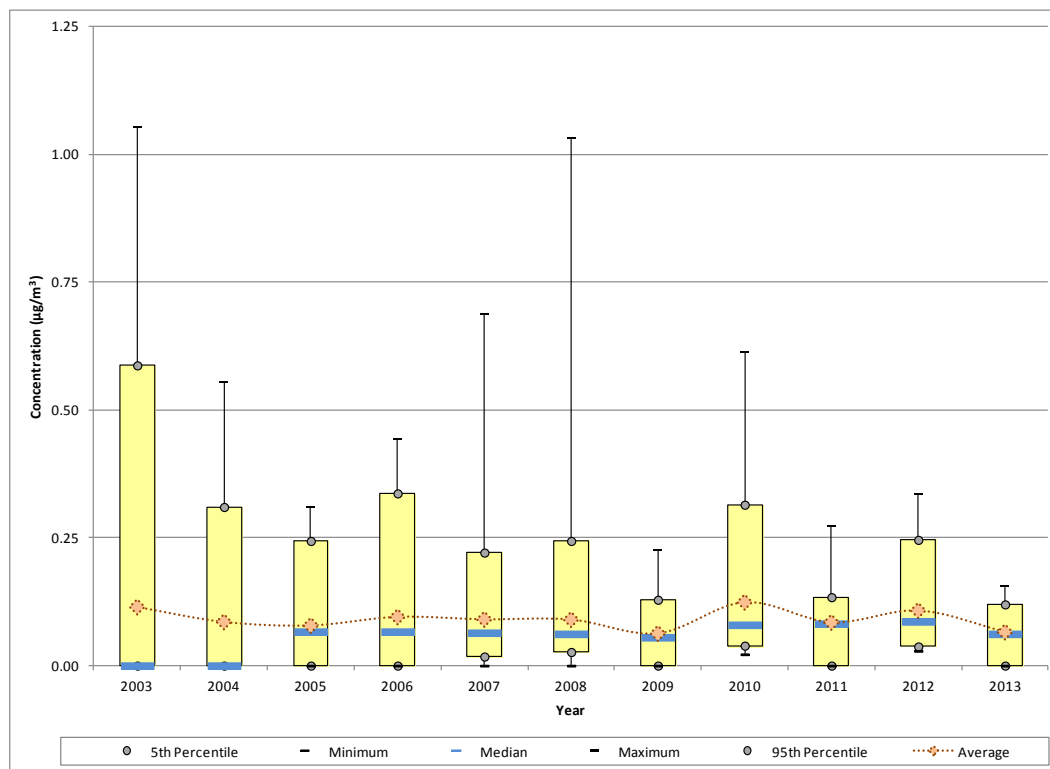


Observations from Figure 19-22 for benzene measurements collected at S4MO include the following:

- Because VOC sampling under the NMP did not begin at S4MO until December 2002, 2002 data was excluded from this analysis.
- All four benzene concentrations greater than $5 \mu\text{g}/\text{m}^3$ were measured in 2003.
- The 1-year average concentrations exhibit a steady decreasing trend through 2007, representing a roughly $1 \mu\text{g}/\text{m}^3$ decrease, although the most significant changes occurred in the early years of sampling. In the years between 2007 and 2011, when the 1-year average concentration has a slight undulating pattern, the 1-year average varied between $0.80 \mu\text{g}/\text{m}^3$ (2011) and $1.03 \mu\text{g}/\text{m}^3$ (2010).
- From 2011 to 2012, the statistical parameters representing the upper end of the concentration range (the maximum and 95th percentile) increased while the statistical parameters representing the lower end of the concentration range (the minimum and 5th percentile) decreased, indicating a widening of concentrations measured. Yet, the 1-year average concentration did not change and the median decreased. The number of concentrations greater than $1 \mu\text{g}/\text{m}^3$ doubled (from six in 2011 to 12 in 2012) while the number of concentrations less than $0.5 \mu\text{g}/\text{m}^3$ increased from two to 11 from 2011 to 2012.

- With the exception of the minimum concentration, all of the statistical parameters are at a minimum for 2013. The change in the 1-year average concentrations between 2003 and 2013 represents a 66 percent decrease in the 1-year average concentrations.

Figure 19-23. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at S4MO

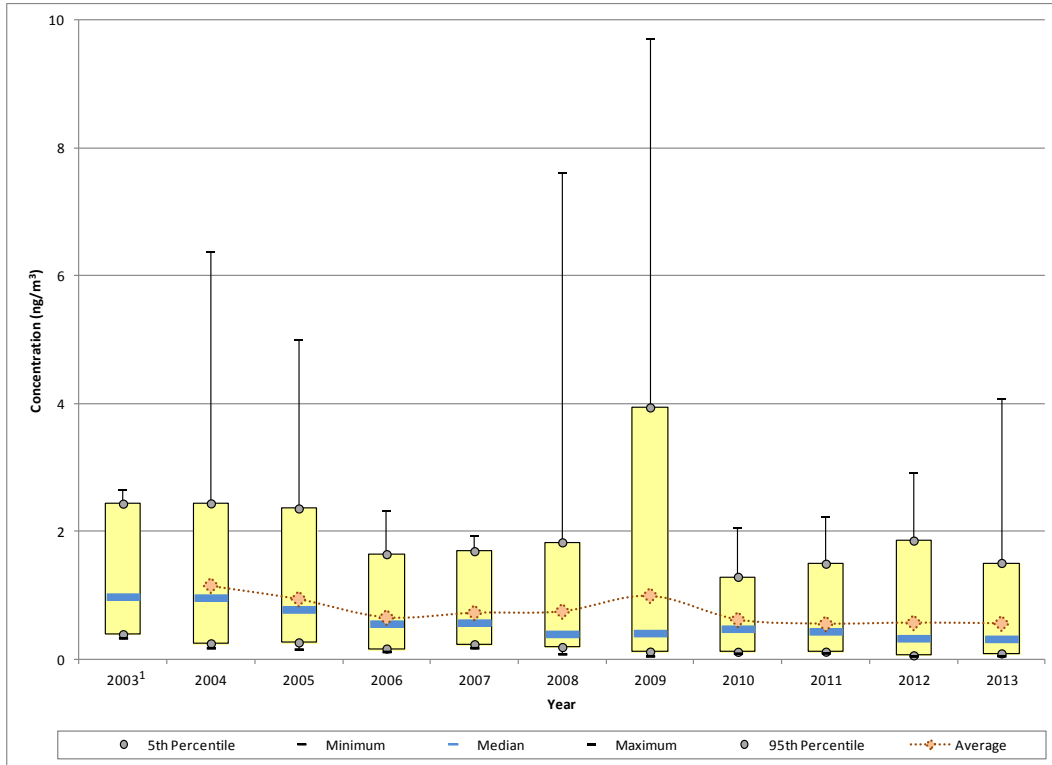


Observations from Figure 19-23 for 1,3-butadiene measurements collected at S4MO include the following:

- The maximum 1,3-butadiene concentration was measured at S4MO in 2003, although a similar concentration was also measured in 2008. These are the only two 1,3-butadiene concentrations greater than $1.0 \mu\text{g}/\text{m}^3$ that have been measured at S4MO.
- The minimum, 5th percentile, and median concentrations are all zero for 2003 and 2004, indicating that at least 50 percent of the measurements were non-detects. The number of non-detects decreased after 2004, from a maximum of 43 non-detects in 2004 to a minimum of zero in 2010 and 2012. After 2006, no more than five non-detects of 1,3-butadiene have been measured at S4MO for any given year.
- Between 2004 and 2008, the 1-year average concentration changed very little, ranging from $0.078 \mu\text{g}/\text{m}^3$ (2005) to $0.095 \mu\text{g}/\text{m}^3$ (2006). Greater fluctuations are shown in the years that follow. Years with a higher number of non-detects, as indicated by a minimum and 5th percentile of zero, such as 2009 and 2011 and 2013, alternate with years without any non-detects (2010 and 2012) and concentrations that

are higher in magnitude, as indicated by the 95th percentile and maximum concentration.

Figure 19-24. Yearly Statistical Metrics for Cadmium (PM₁₀) Concentrations Measured at S4MO



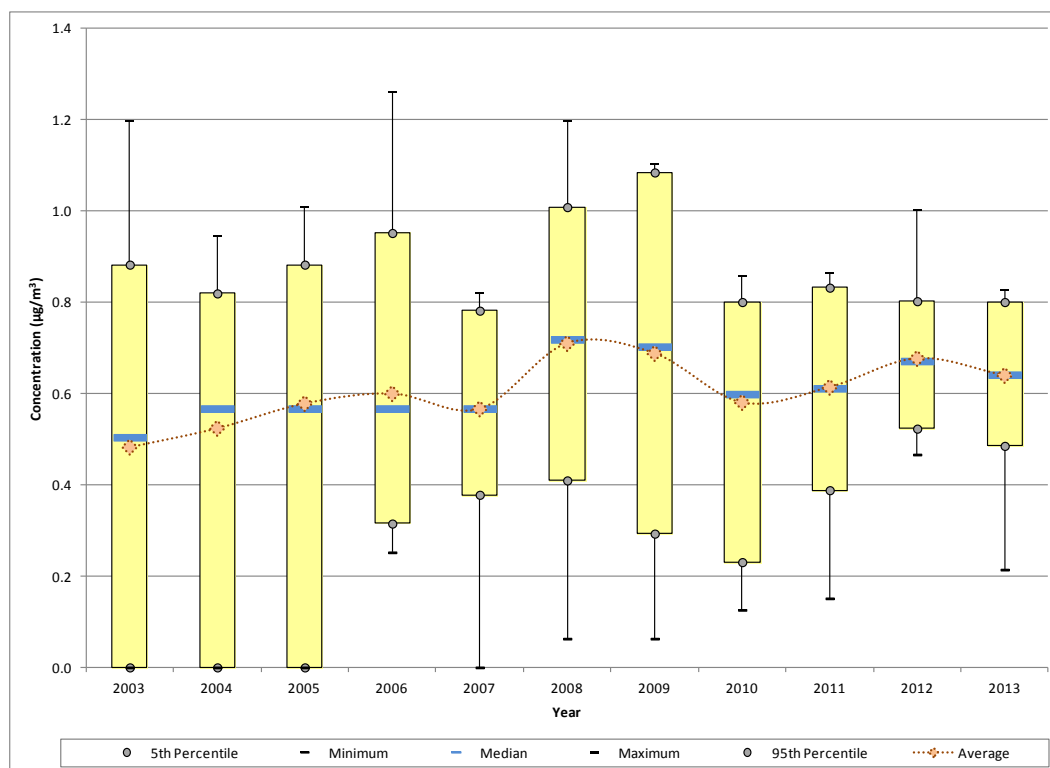
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2003.

Observations from Figure 19-24 for cadmium measurements collected at S4MO include the following:

- The maximum cadmium concentration was measured in 2009 (9.71 ng/m³). The five cadmium concentrations greater than 5 ng/m³ were measured at S4MO in 2004 (one), 2008 (two), and 2009 (two).
- A steady decreasing trend is shown in the 1-year average and median concentrations through 2006. Even though the 1-year average concentration exhibits an increasing trend between 2006 and 2009, the median concentration does not, and actually continued decreasing during most of this time. This indicates that concentrations at the upper end of the concentration range are driving the 1-year averages, particularly for 2008 and 2009, while the concentrations at the lower end of the concentration range are accounting for a higher percentage of measurements.
- The range of concentrations measured decreased significantly from 2009 to 2010.

- Even though the range of concentrations increased every year between 2010 and 2013, the 1-year average concentration changed little while the median exhibits a slight decreasing trend, reaching a minimum for 2013.

Figure 19-25. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at S4MO

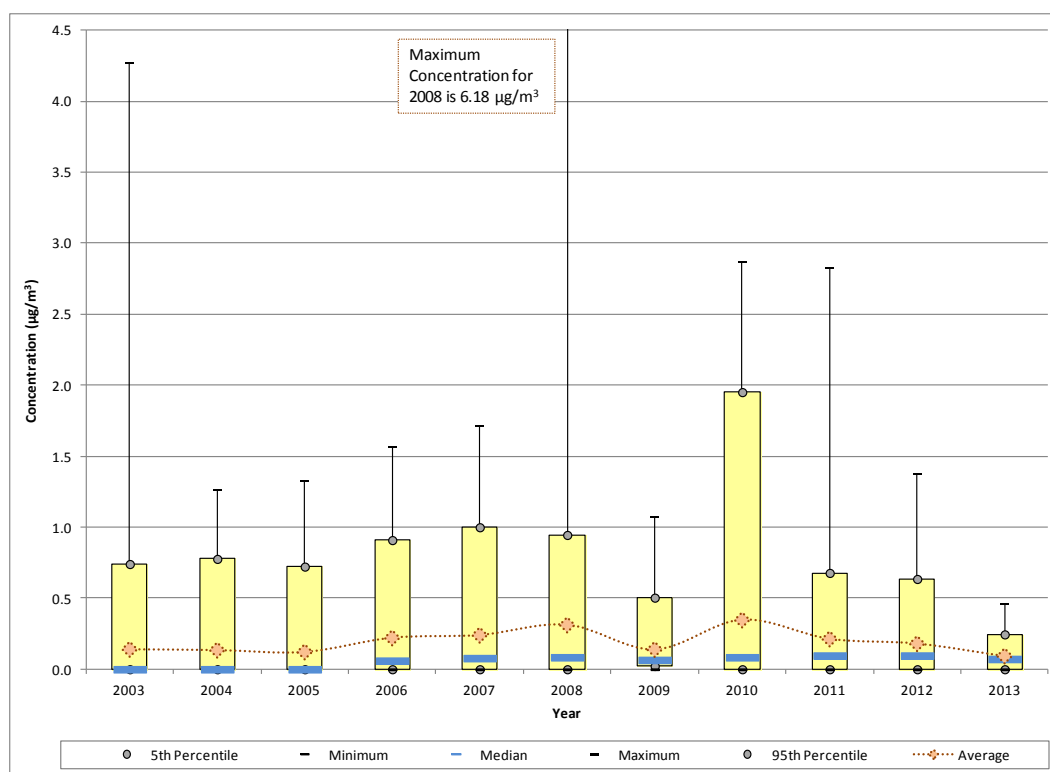


Observations from Figure 19-25 for carbon tetrachloride measurements collected at S4MO include the following:

- Twenty of the 21 non-detects of carbon tetrachloride were measured at S4MO in 2003, 2004, or 2005, with a single non-detect measured in 2007.
- A steady increasing trend in the 1-year average concentration is shown through 2006. Although the maximum concentration decreased substantially from 2006 to 2007 (and a non-detect was measured), the change in the 1-year average concentration is slight and the median concentration did not change at all. In fact, the median concentration is steady between 2005 and 2007.
- All of the statistical parameters exhibit increases from 2007 to 2008.
- Both the median and 1-year average concentrations have a decreasing trend between 2008 and 2010, with the largest change shown for 2010.

- Between 2010 and 2012, the 1-year average concentrations have a significant increasing trend even as the majority of concentrations measured are falling into a tighter range, as indicated by the decreasing difference between the 5th and 95th percentiles for these years.
- Nearly all of the statistical parameters exhibit decreases for 2013, which is mostly a result of a larger number of concentrations at the lower end of the concentration range. Three concentrations measured in 2013 are less than the minimum concentration measured in 2012. Further, the number of concentrations less than $0.6 \mu\text{g}/\text{m}^3$ increased from 2012 to 2013 (from nine in 2012 to 20 in 2013).

Figure 19-26. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at S4MO



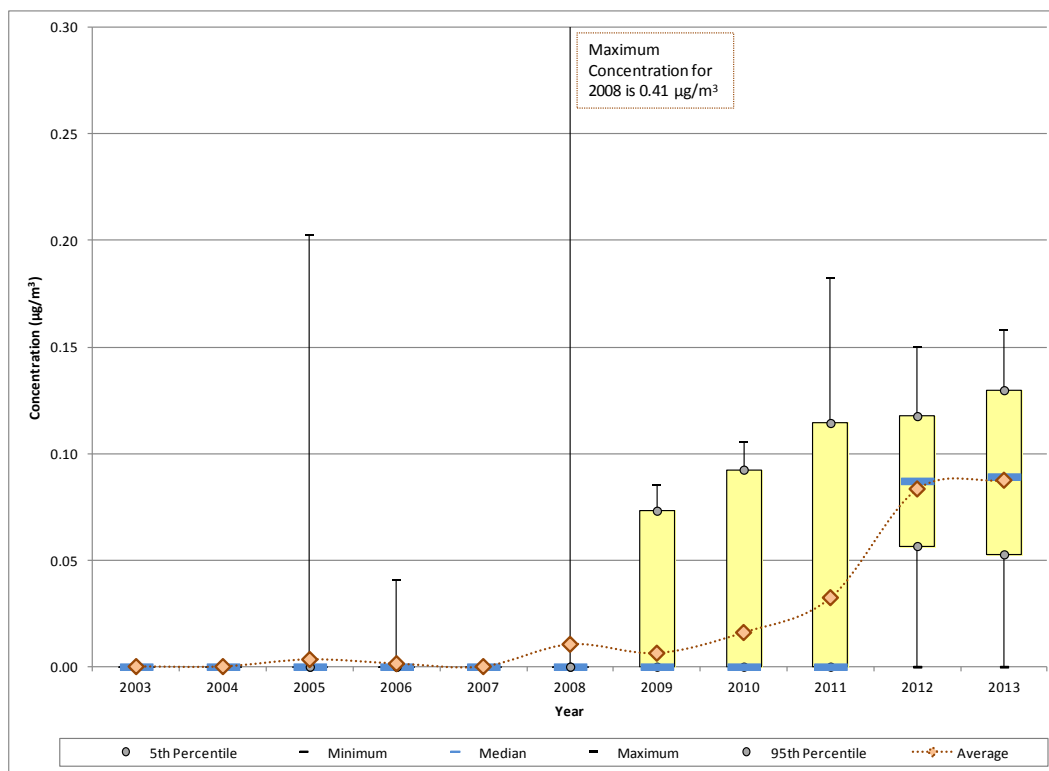
Observations from Figure 19-26 for *p*-dichlorobenzene measurements collected at S4MO include the following:

- The minimum, 5th percentile, and median concentrations are all zero for 2003, 2004, and 2005, indicating that at least 50 percent of the measurements were non-detects. The percentage of non-detects was at a maximum in 2003 (90 percent), after which the percentage decreased, reaching a minimum of 5 percent for 2009. The percentage of non-detects varied between 10 percent and 20 percent each year following 2009.
- After little change in the early years, the 1-year average and median concentrations exhibit a steady increasing trend between 2005 and 2008. However, the relatively

large number of non-detects (zeros) combined with the range of measured detections result in a relatively high level of variability, based on the confidence intervals calculated for the 1-year averages. This is particularly true for 2008, when the maximum *p*-dichlorobenzene concentration was measured ($6.18 \mu\text{g}/\text{m}^3$). The difference between the median and 1-year average concentration is also an indicator of this variability. During this period, the 1-year average was at least three times greater than the median.

- The concentrations measured decreased considerably from 2008 to 2009 then increased again in 2010. Concentrations measured in 2010 were higher and more variable than those measured in 2009. Five concentrations measured in 2010 were greater than the maximum concentration measured in 2009 and the number of concentrations greater than $0.5 \mu\text{g}/\text{m}^3$ more than doubled, from four in 2009 to 10 for 2010. At the same time, the number of non-detects increased from three in 2009 to eight in 2010.
- Although the range of concentrations measured in 2011 is similar to the range of concentrations measured in 2010, the 95th percentile and 1-year average concentration decreased. Further decreases are shown for these parameters for 2012. Yet, the median concentration increased slightly for 2011 and then did not change for 2012.
- Several of the statistical parameters are at a minimum for 2013, including the 1-year average concentration, which is less than $0.1 \mu\text{g}/\text{m}^3$ for the first time. This year has the smallest range of concentrations measured by a considerable margin.

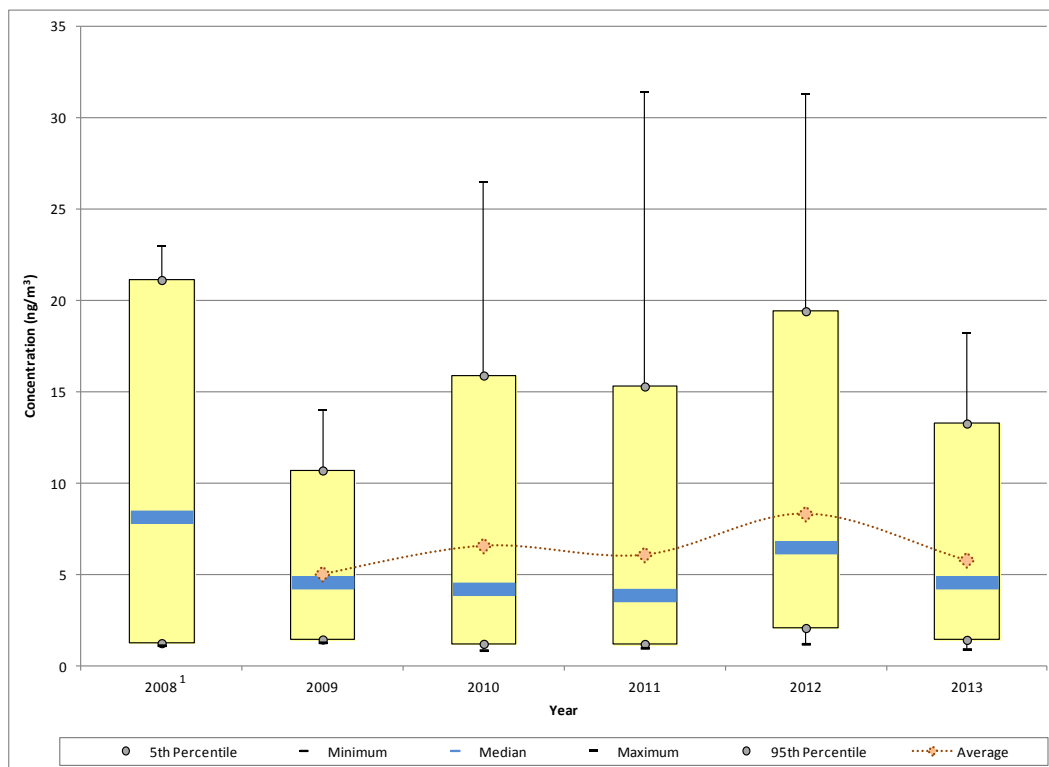
Figure 19-27. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at S4MO



Observations from Figure 19-27 for 1,2-dichloroethane measurements collected at S4MO include the following:

- With the exception of 2012 and 2013, the median concentration is zero for all years, indicating that at least 50 percent of the measurements were non-detects. There were no measured detections of 1,2-dichloroethane in 2003, 2004, or 2007, one measured detection in 2005, and two each in 2006 and 2008. Beginning in 2009, the number of measured detections increased steadily, from five in 2009, to 10 in 2010, 18 in 2011, 56 in 2012, and 58 in 2013.
- As the number of measured detections increased in the later years of sampling, each of the corresponding statistical metrics shown in Figure 19-27 also increased. The 5th percentile and median concentrations are greater than zero for the first time in 2012, when measured detections accounted for a majority of the measurements for the first time.

Figure 19-28. Yearly Statistical Metrics for Fluorene Concentrations Measured at S4MO

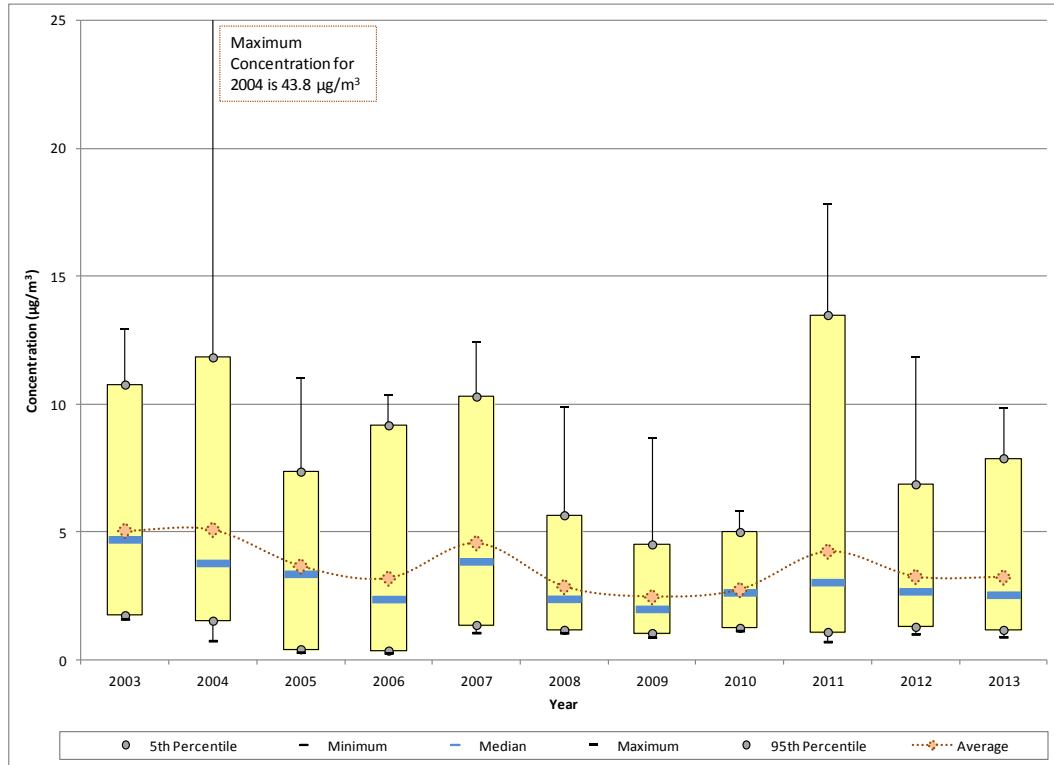


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 19-28 for fluorene measurements collected at S4MO include the following:

- The box and whisker plots for fluorene measurements resemble the plots for acenaphthene presented in Figure 19-23.
- Two measurements greater than 30 ng/m³ have been measured at S4MO, one on July 2, 2011 (31.4 ng/m³) and one on July 2, 2012 (31.3 ng/m³).
- Several of the statistical parameters shown exhibit decreases from 2008 to 2009. From 2009 to 2010, the range of concentrations measured increased but the median concentration decreased, a trend that continued into 2011. A similar observation was made for acenaphthene.
- With the exception of the maximum concentration, the statistical parameters exhibit increases from 2011 to 2012. This is because the number of measurements at the upper end of the range increased while the number of measurements at the lower end of the concentration range decreased. The number of concentrations greater than 10 ng/m³ increased from 13 to 22 from 2011 to 2012; conversely, the number of concentrations less than 2 ng/m³ decreased from 11 to three from 2011 to 2012.
- All of the statistical parameters exhibit decreases for 2013.

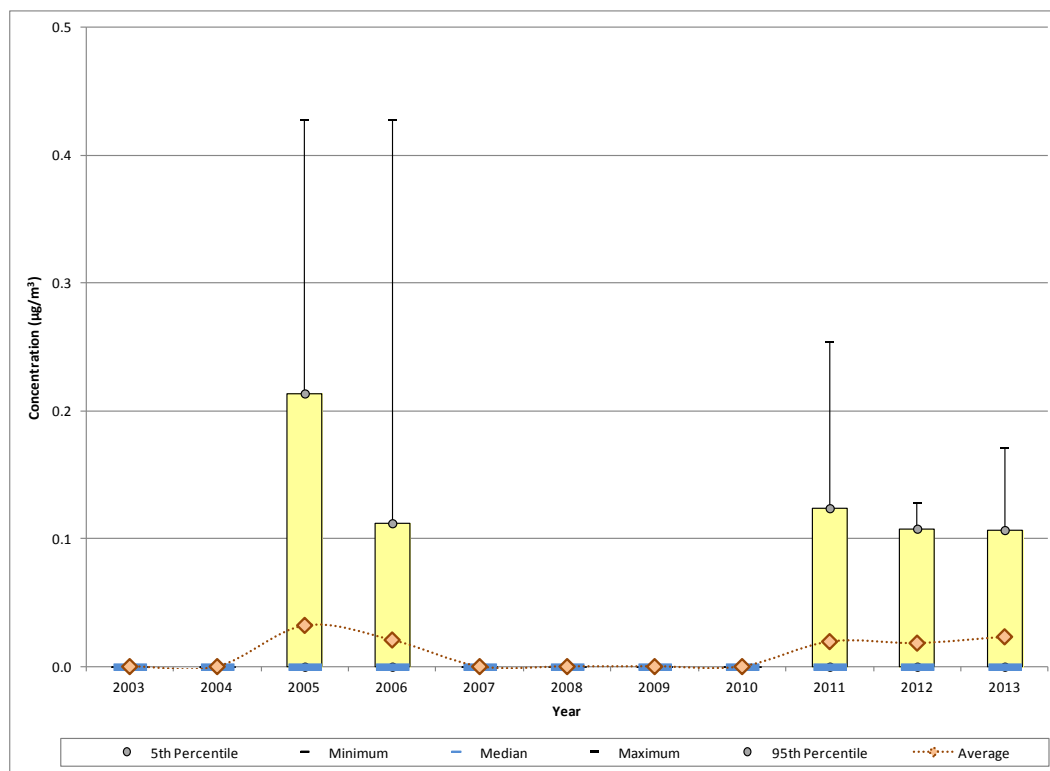
Figure 19-29. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at S4MO



Observations from Figure 19-29 for formaldehyde measurements collected at S4MO include the following:

- The maximum formaldehyde concentration ($43.8 \mu\text{g}/\text{m}^3$) was measured in 2004 on the same day that the maximum acetaldehyde concentration was measured (August 31, 2004). This concentration is more than twice the next highest concentration ($17.8 \mu\text{g}/\text{m}^3$), which was measured in 2011. The six highest concentrations of formaldehyde were all measured in 2004 (2) or 2011 (4).
- The 1-year average concentration has a decreasing trend between 2004 and 2006. After the increase shown for 2007, the decreasing trend resumed through 2009, when the 1-year average was at a minimum ($2.46 \mu\text{g}/\text{m}^3$). The 1-year average concentration did not change significantly between 2009 and 2010, even though the smallest range of concentrations was measured in 2010.
- Most of the statistical parameters exhibit considerable increases from 2010 to 2011. There were 11 concentrations of formaldehyde measured in 2011 that were greater than the maximum concentration measured in 2010.
- Most of the statistical parameters exhibit decreases from 2011 to 2012.
- The central tendency statistics exhibit little change from 2012 to 2013.

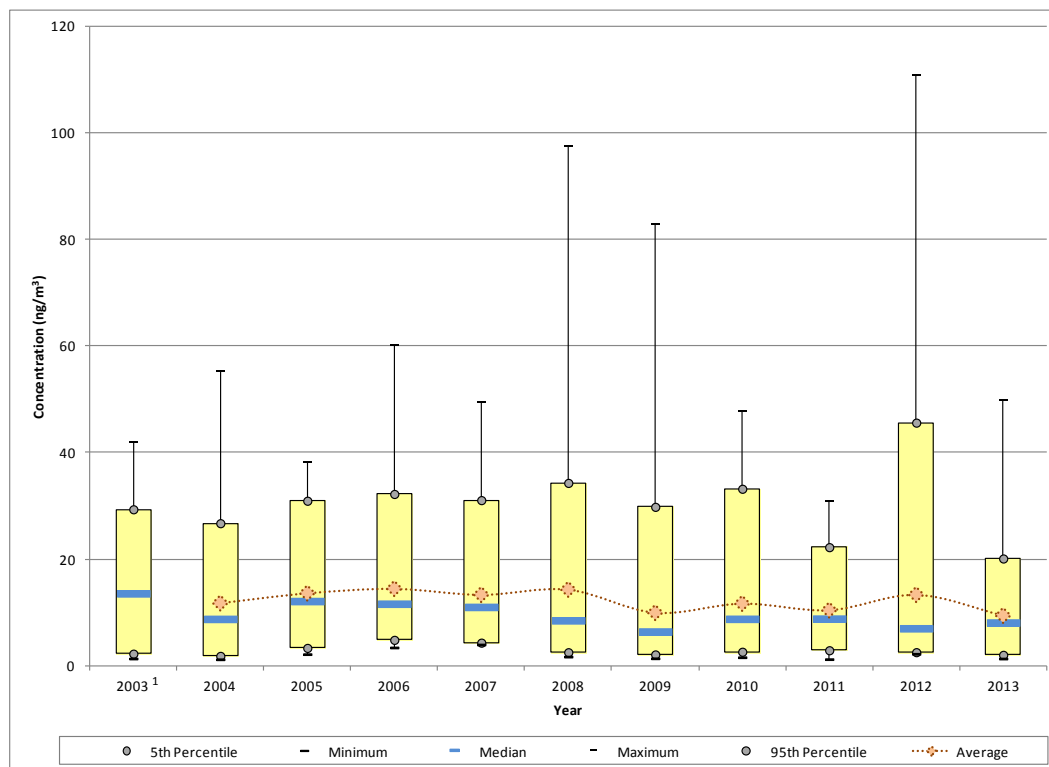
Figure 19-30. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at S4MO



Observations from Figure 19-30 for hexachloro-1,3-butadiene measurements collected at S4MO include the following:

- The median concentration of hexachloro-1,3-butadiene for each year of sampling is zero, indicating that at least 50 percent of the measurements were non-detects. For 2003, 2004, and 2007 through 2010, 100 percent of the measurements were non-detects.
- For 2005 and 2006, the percentage of measured detections was less than 15 percent. For 2011, measured detections accounted for 16 percent of the measurements. For 2012, that number increased to 22 percent and then up to 26 percent for 2013. Additional years of sampling are needed to determine if the number of measured detections will continue to increase.
- The 1-year average concentration has varied little over the last 3 years of sampling, from 0.018 $\mu\text{g}/\text{m}^3$ (2012) to 0.023 $\mu\text{g}/\text{m}^3$ (2013).

Figure 19-31. Yearly Statistical Metrics for Lead (PM₁₀) Concentrations Measured at S4MO

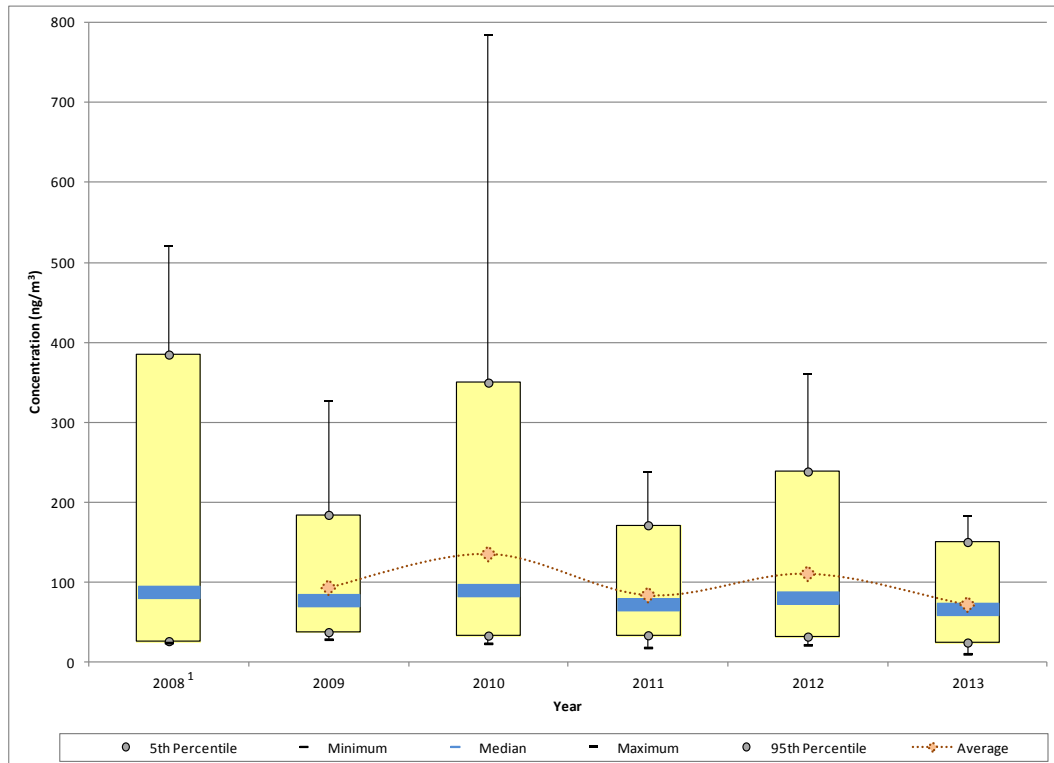


¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2003.

Observations from Figure 19-31 for lead measurements collected at S4MO include the following:

- The maximum lead concentration was measured at S4MO in 2012 (111 ng/m³). This is the only measurement greater than 100 ng/m³ measured at S4MO.
- The 95th percentile for 2012 is greater than the 95th percentiles for all other years as well as the maximum concentration for some years. Even though the maximum, 95th percentile, and 1-year average concentration increased from 2011 to 2012, as there were five measurements in 2012 greater than the maximum concentration measured in 2011, the median concentration decreased. This is due to an increase in the number of measurements at the lower end of the concentration range. For example, concentrations less than 7 ng/m³ account for more than half of the concentrations measured in 2012, up from 31 percent in 2011.
- The 1-year average concentration of lead at S4MO has fluctuated over the years and exhibits no real trend. The 1-year average concentrations have ranged from 9.40 ng/m³ (2013) to 14.46 ng/m³ (2006). The confidence intervals calculated for these averages are relatively large and indicate a considerable amount of variability in the measurements. The 1-year average concentration is at a minimum concentration for 2013.

Figure 19-32. Yearly Statistical Metrics for Naphthalene Concentrations Measured at S4MO

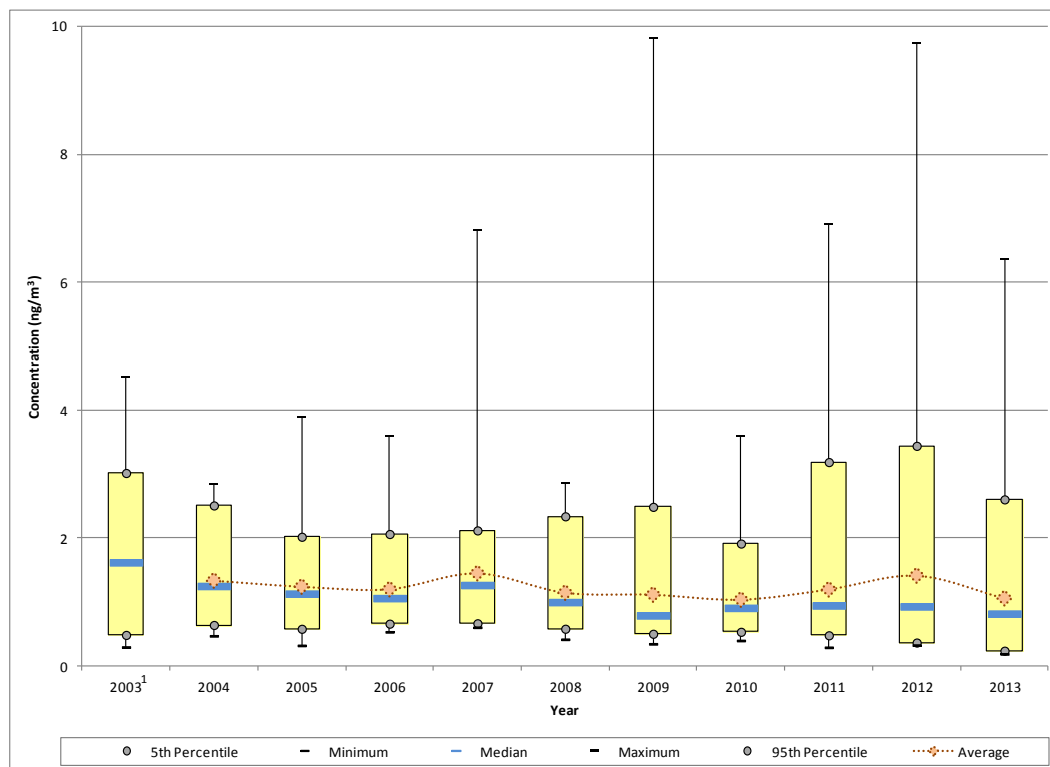


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 19-32 for naphthalene measurements collected at S4MO include the following:

- Naphthalene concentrations measured at S4MO exhibit considerable variability, ranging from 10.1 ng/m³ (2013) to 784 ng/m³ (2010).
- The 1-year average concentration has ranged from 71.92 ng/m³ (2013) to 135 ng/m³ (2010). The median varies less, ranging from 66.30 ng/m³ (2013) to 89.85 ng/m³ (2010). All of the statistical parameters are at a minimum for 2013.
- The years when rather high concentrations were measured alternate with years when the maximum concentration is considerably less, resulting in the 1-year average (and median) concentrations having an undulating pattern.

Figure 19-33. Yearly Statistical Metrics for Nickel (PM₁₀) Concentrations Measured at S4MO



¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2003.

Observations from Figure 19-33 for nickel measurements collected at S4MO include the following:

- The two highest nickel concentrations were measured in 2009 (9.82 ng/m³) and 2012 (9.74 ng/m³). No other concentrations greater than 7 ng/m³ have been measured at S4MO.
- The 1-year average concentration has ranged from 1.04 ng/m³ (2010) to 1.45 ng/m³ (2007). The slight decreasing trend shown between 2004 and 2010 was interrupted by the increase shown for 2007. This year has the highest minimum concentration, the second fewest measurements less than 1 ng/m³, and the fourth highest concentration measured at S4MO.
- The 1-year average, 95th percentile, and maximum concentrations exhibit an increasing trend between 2010 and 2012. However, the wide range of concentrations measured results in relatively large confidence intervals, indicating that the change is not statistically significant.
- Several of the lowest nickel concentrations were measured at S4MO in 2013, including the lowest minimum concentration. This year has the greatest number of nickel concentrations less than 0.5 ng/m³ (nine).

19.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the S4MO monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

19.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for S4MO and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 19-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Observations for S4MO from Table 19-6 include the following:

- The pollutants with the highest annual average concentrations for S4MO are formaldehyde, acetaldehyde, carbon tetrachloride, and benzene.
- The same four pollutants have the highest cancer risk approximations for S4MO, although the order is different. However, formaldehyde's cancer risk approximation for S4MO (42.05 in-a-million) is an order of magnitude higher than the cancer risk approximations for these other pollutants.
- Benzene has the highest cancer risk approximation for S4MO among the VOCs (4.74 in-a-million); arsenic has the highest cancer risk approximation for S4MO among the metals (3.14 in-a-million); and naphthalene has the highest cancer risk approximation for S4MO among the PAHs (2.45 in-a-million).
- None of the pollutants of interest for S4MO have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation is formaldehyde (0.33).

Table 19-6. Risk Approximations for the Missouri Monitoring Site

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
St. Louis, Missouri - S4MO						
Acetaldehyde	0.0000022	0.009	61/61	1.98 ± 0.22	4.35	0.22
Benzene	0.0000078	0.03	61/61	0.61 ± 0.05	4.74	0.02
1,3-Butadiene	0.00003	0.002	57/61	0.07 ± 0.01	1.97	0.03
Carbon Tetrachloride	0.000006	0.1	61/61	0.64 ± 0.03	3.84	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	47/61	0.09 ± 0.02	1.03	<0.01
1,2-Dichloroethane	0.000026	2.4	58/61	0.09 ± 0.01	2.27	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.23 ± 0.55	42.05	0.33
Hexachloro-1,3-butadiene	0.000022	0.09	17/61	0.02 ± 0.01	0.53	<0.01
Acenaphthene ^a	0.000088	--	60/60	5.02 ± 1.16	0.44	--
Arsenic (PM ₁₀) ^a	0.0043	0.000015	61/61	0.73 ± 0.08	3.14	0.05
Cadmium (PM ₁₀) ^a	0.0018	0.00001	61/61	0.56 ± 0.18	1.01	0.06
Fluorene ^a	0.000088	--	60/60	5.79 ± 1.07	0.51	--
Lead (PM ₁₀) ^a	--	0.00015	61/61	9.40 ± 2.01	--	0.06
Naphthalene ^a	0.000034	0.003	60/60	71.92 ± 10.08	2.45	0.02
Nickel (PM ₁₀) ^a	0.00048	0.00009	61/61	1.06 ± 0.26	0.51	0.01

-- = A Cancer URE or Noncancer RfC is not available.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m³ for ease of viewing.

19.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 19-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 19-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 19-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for S4MO, as presented in Table 19-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 19-7. Table 19-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 19.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 19-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Missouri Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
St. Louis, Missouri (St. Louis City) - S4MO					
Formaldehyde	86.19	Formaldehyde	1.12E-03	Formaldehyde	42.05
Benzene	85.02	Hexavalent Chromium	7.89E-04	Benzene	4.74
Ethylbenzene	48.46	Benzene	6.63E-04	Acetaldehyde	4.35
Acetaldehyde	46.53	1,3-Butadiene	3.78E-04	Carbon Tetrachloride	3.84
Trichloroethylene	15.45	Naphthalene	3.26E-04	Arsenic	3.14
1,3-Butadiene	12.60	Arsenic, PM	2.49E-04	Naphthalene	2.45
Naphthalene	9.59	POM, Group 2b	1.80E-04	1,2-Dichloroethane	2.27
Tetrachloroethylene	5.83	POM, Group 2d	1.44E-04	1,3-Butadiene	1.97
Dichloromethane	3.65	Ethylbenzene	1.21E-04	<i>p</i> -Dichlorobenzene	1.03
POM, Group 2b	2.05	Acetaldehyde	1.02E-04	Cadmium	1.01

Table 19-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Missouri Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
St. Louis, Missouri (St. Louis City) - S4MO					
Toluene	313.06	Acrolein	268,853.09	Formaldehyde	0.33
Hexane	226.91	Formaldehyde	8,795.13	Acetaldehyde	0.22
Methanol	208.08	Trichloroethylene	7,726.86	Lead	0.06
Xylenes	196.63	1,3-Butadiene	6,302.24	Cadmium	0.06
Formaldehyde	86.19	Acetaldehyde	5,170.07	Arsenic	0.05
Benzene	85.02	Arsenic, PM	3,864.62	1,3-Butadiene	0.03
Hydrochloric acid	70.78	Hydrochloric acid	3,539.11	Naphthalene	0.02
Ethylene glycol	64.32	Cadmium, PM	3,474.08	Benzene	0.02
Ethylbenzene	48.46	Lead, PM	3,349.14	Nickel	0.01
Acetaldehyde	46.53	Naphthalene	3,195.33	Carbon Tetrachloride	0.01

Observations from Table 19-7 include the following:

- Formaldehyde, benzene, and ethylbenzene are the highest emitted pollutants with cancer UREs in the city of St. Louis.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, hexavalent chromium, and benzene.
- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions.
- Formaldehyde tops all three lists, with the highest quantity emitted, the highest toxicity-weighted emissions, and the highest cancer risk approximation. Benzene, acetaldehyde, naphthalene, and 1,3-butadiene also appear on all three lists.
- Arsenic has the fifth highest cancer risk approximation for S4MO. While arsenic is not one of the highest emitted pollutants in the city of St. Louis, it ranks sixth for its toxicity-weighted emissions. Carbon tetrachloride, 1,2-dichloroethane, *p*-dichlorobenzene, and cadmium also appear among the pollutants of interest with the highest cancer risk approximations for S4MO but none of these appear on either emissions-based list.
- POM, Group 2b is the 10th highest emitted “pollutant” in St. Louis and ranks seventh for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at S4MO including acenaphthene and fluorene, which are pollutants of interest for S4MO. These pollutants are not among those with the highest cancer risk approximations for S4MO.

Observations from Table 19-8 include the following:

- Toluene, hexane, and methanol are the highest emitted pollutants with noncancer RfCs in the city of St. Louis.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and trichloroethylene. Although acrolein was sampled for at S4MO, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.
- Three of the highest emitted pollutants in the city of St. Louis also have the highest toxicity-weighted emissions.
- Formaldehyde, the pollutant with highest noncancer hazard approximation, has the second highest toxicity-weighted emissions and the fifth highest total emissions. Acetaldehyde also appears on all three lists.

- Three of S4MO's metal pollutants of interest (lead, arsenic, and cadmium) appear among the pollutants with the highest toxicity-weighted emissions, but none of these are among the highest emitted.

19.6 Summary of the 2013 Monitoring Data for S4MO

Results from several of the data treatments described in this section include the following:

- ❖ *Twenty-one pollutants failed screens for S4MO. S4MO failed the highest number of screens among all NMP sites, similar to previous years.*
- ❖ *Formaldehyde and acetaldehyde have the highest annual average concentrations for S4MO. These are the only pollutants of interest with annual averages greater than 1 $\mu\text{g}/\text{m}^3$.*
- ❖ *S4MO has the second highest annual average concentration of hexachloro-1,3-butadiene and the fourth highest annual average concentration of p-dichlorobenzene among NMP sites sampling VOCs. S4MO also has the fifth highest annual average concentration of arsenic among sites sampling PM_{10} metals.*
- ❖ *Concentrations of acetaldehyde measured at S4MO have decreased significantly since 2010. Concentrations of benzene have an overall decreasing trend as well, with some of the lowest concentrations measured in 2013. Some of the lowest concentrations of pollutants such as arsenic, p-dichlorobenzene, and naphthalene were measured in 2013. In addition, the detection rate of 1,2-dichloroethane has been increasing steadily at S4MO over the last few years of sampling.*
- ❖ *Formaldehyde has the highest cancer risk approximation of the pollutants of interest for S4MO. None of the pollutants of interest have noncancer hazard approximations greater than an HQ of 1.0.*

20.0 Sites in New Jersey

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at UATMP sites in New Jersey, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

20.1 Site Characterization

This section characterizes the New Jersey monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring data.

One New Jersey monitoring site (CSNJ) is located in the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD CBSA while the other three New Jersey sites are located within the New York-Newark-Jersey City, NY-NJ-PA CBSA. Figure 20-1 is a composite satellite image retrieved from ArcGIS Explorer showing the CSNJ monitoring site and its immediate surroundings. Figure 20-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 20-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Figures 20-3 through 20-7 are the composite satellite maps and emissions source maps for CHNJ, ELNJ, and NBNJ. Table 20-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 20-1. Camden, New Jersey (CSNJ) Monitoring Site

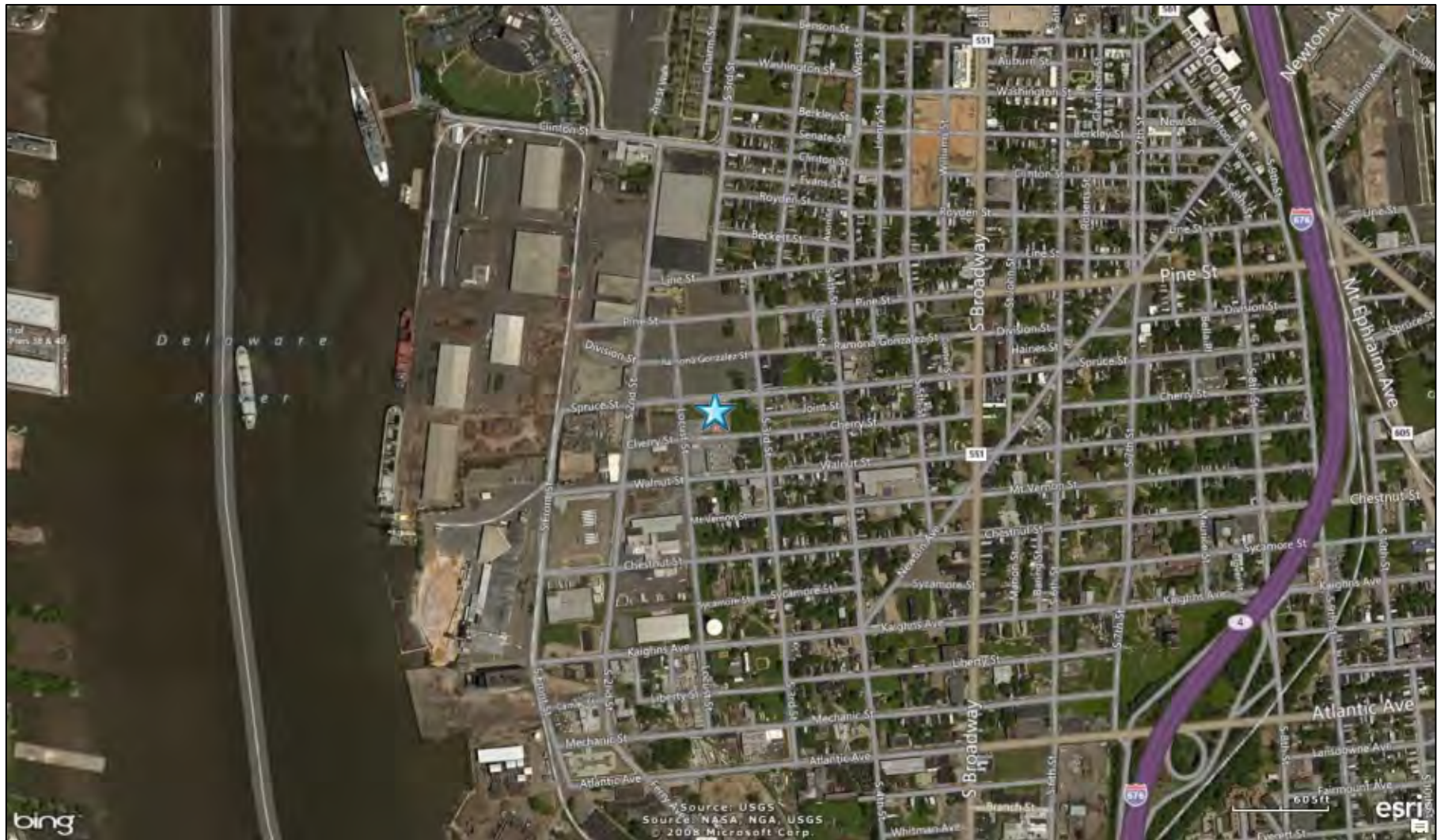


Figure 20-2. NEI Point Sources Located Within 10 Miles of CSNJ

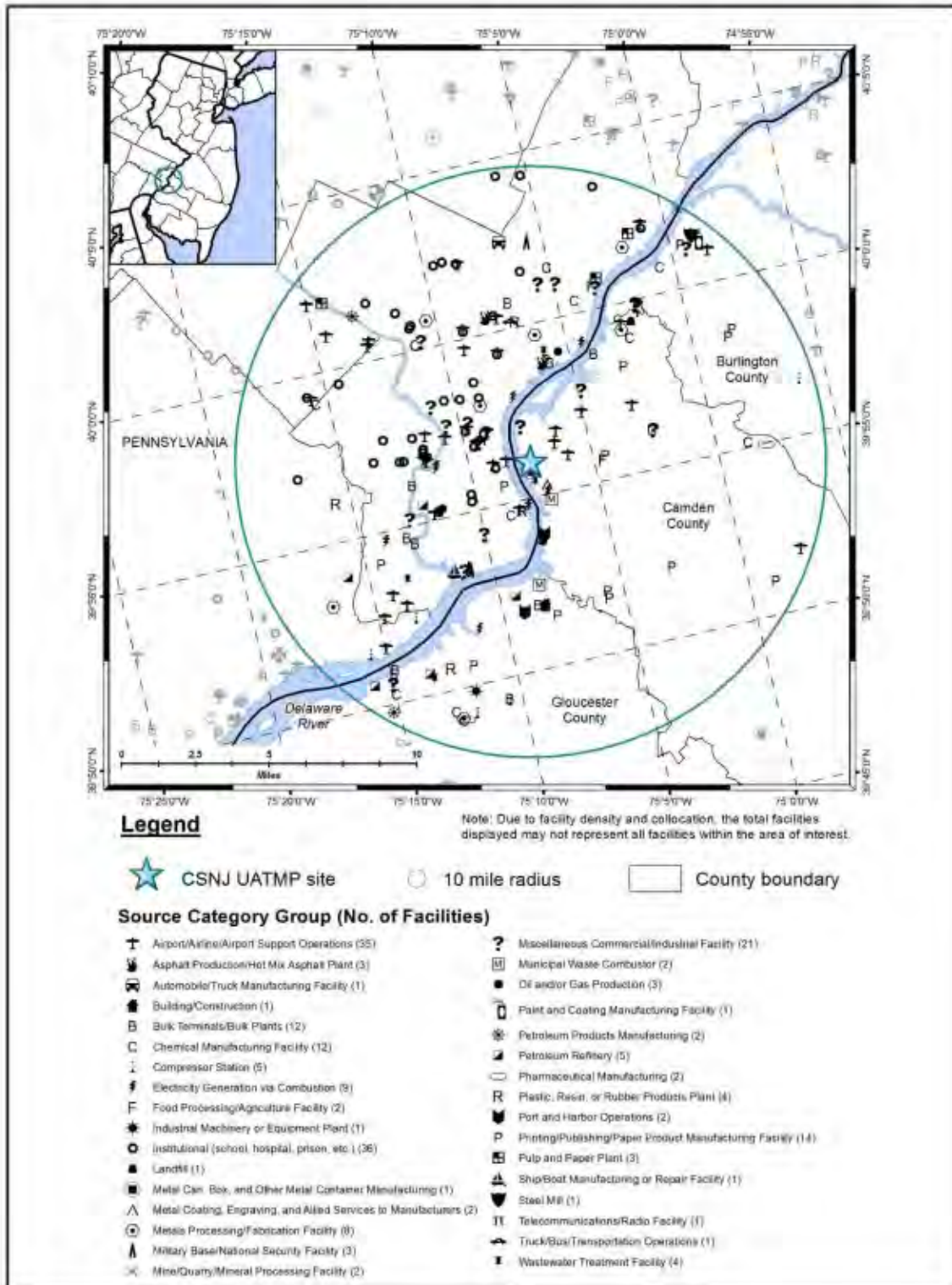


Figure 20-3. Chester, New Jersey (CHNJ) Monitoring Site

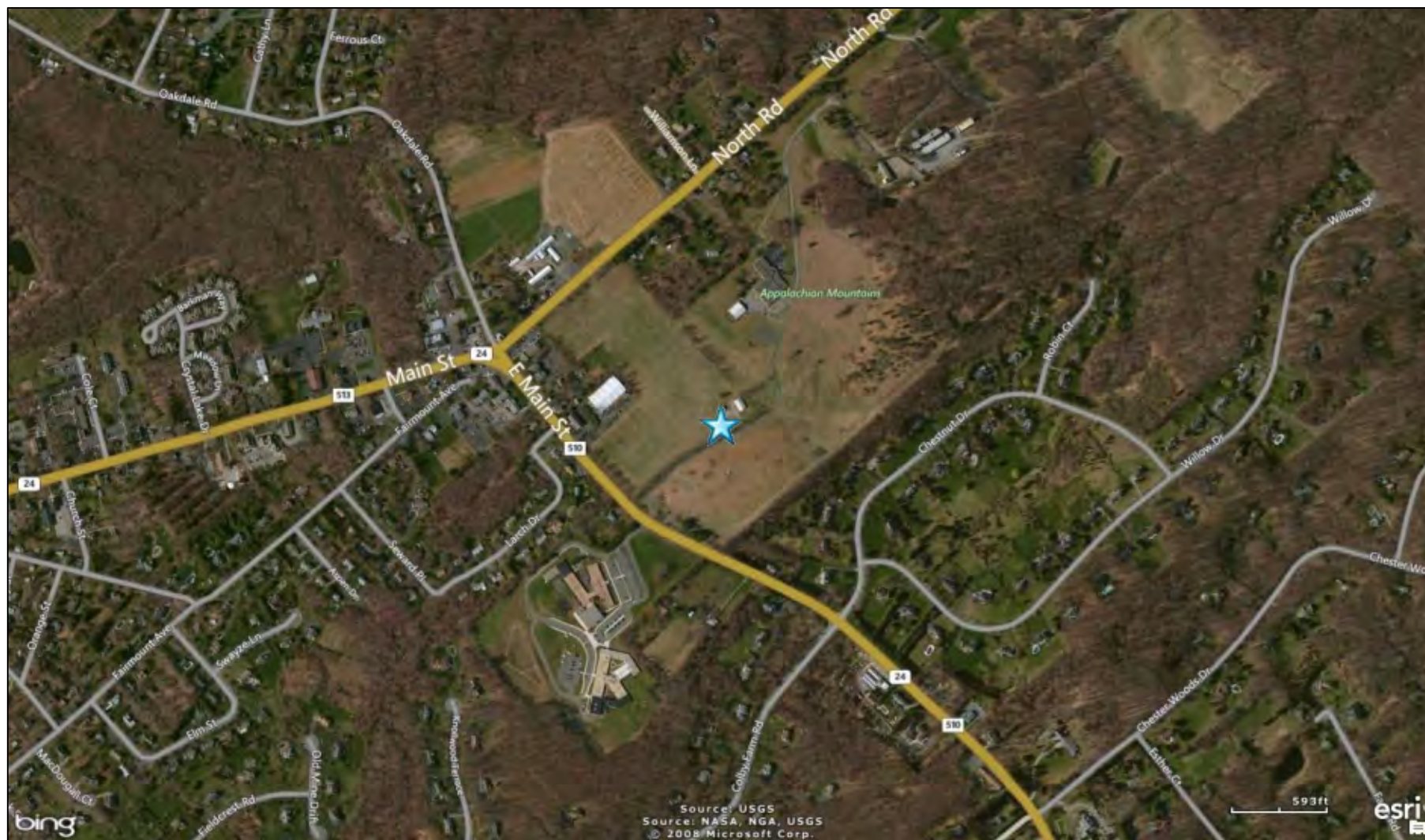


Figure 20-4. NEI Point Sources Located Within 10 Miles of CHNJ

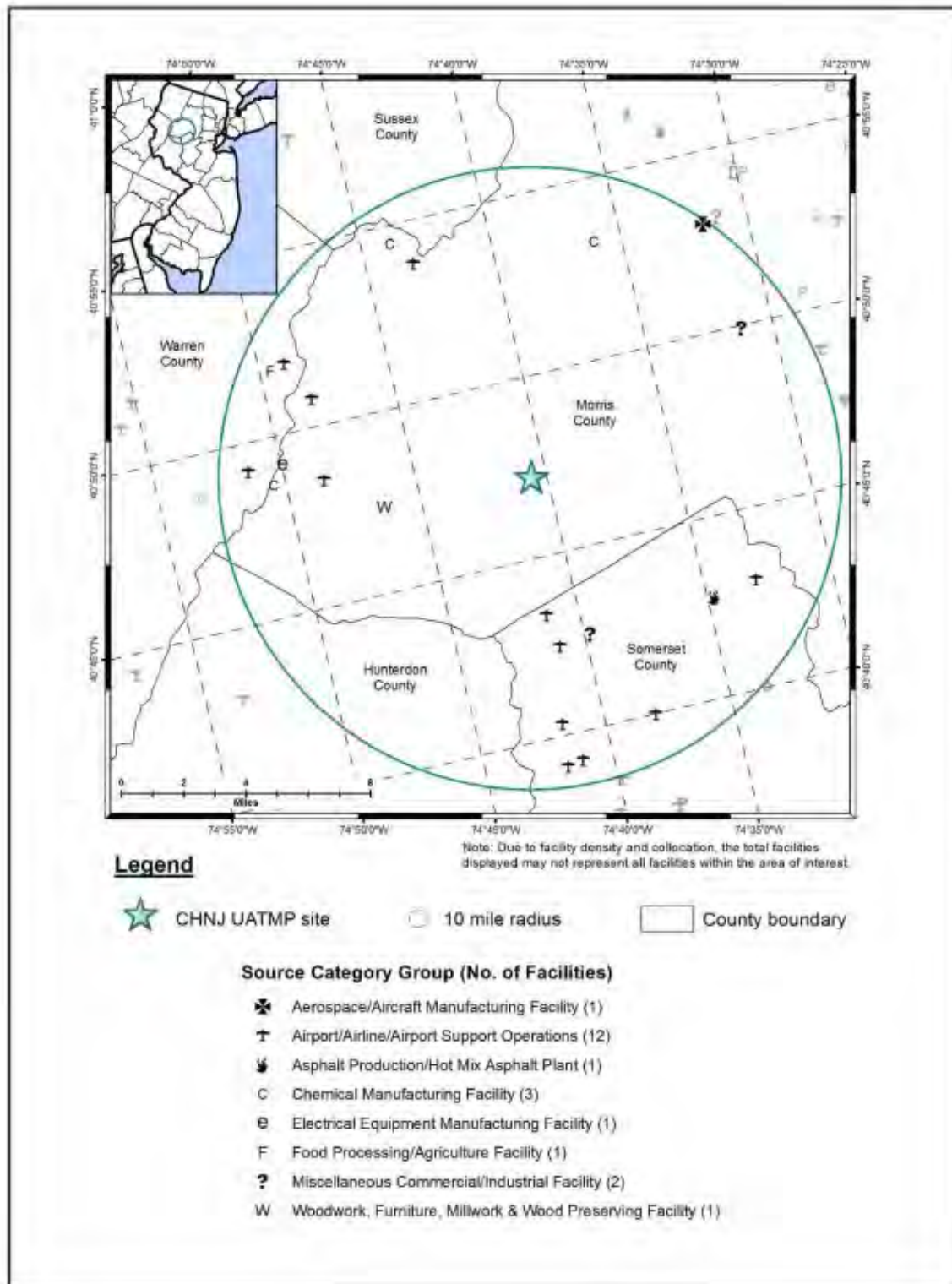


Figure 20-5. Elizabeth, New Jersey (ELNJ) Monitoring Site



Figure 20-6. North Brunswick, New Jersey (NBNJ) Monitoring Site

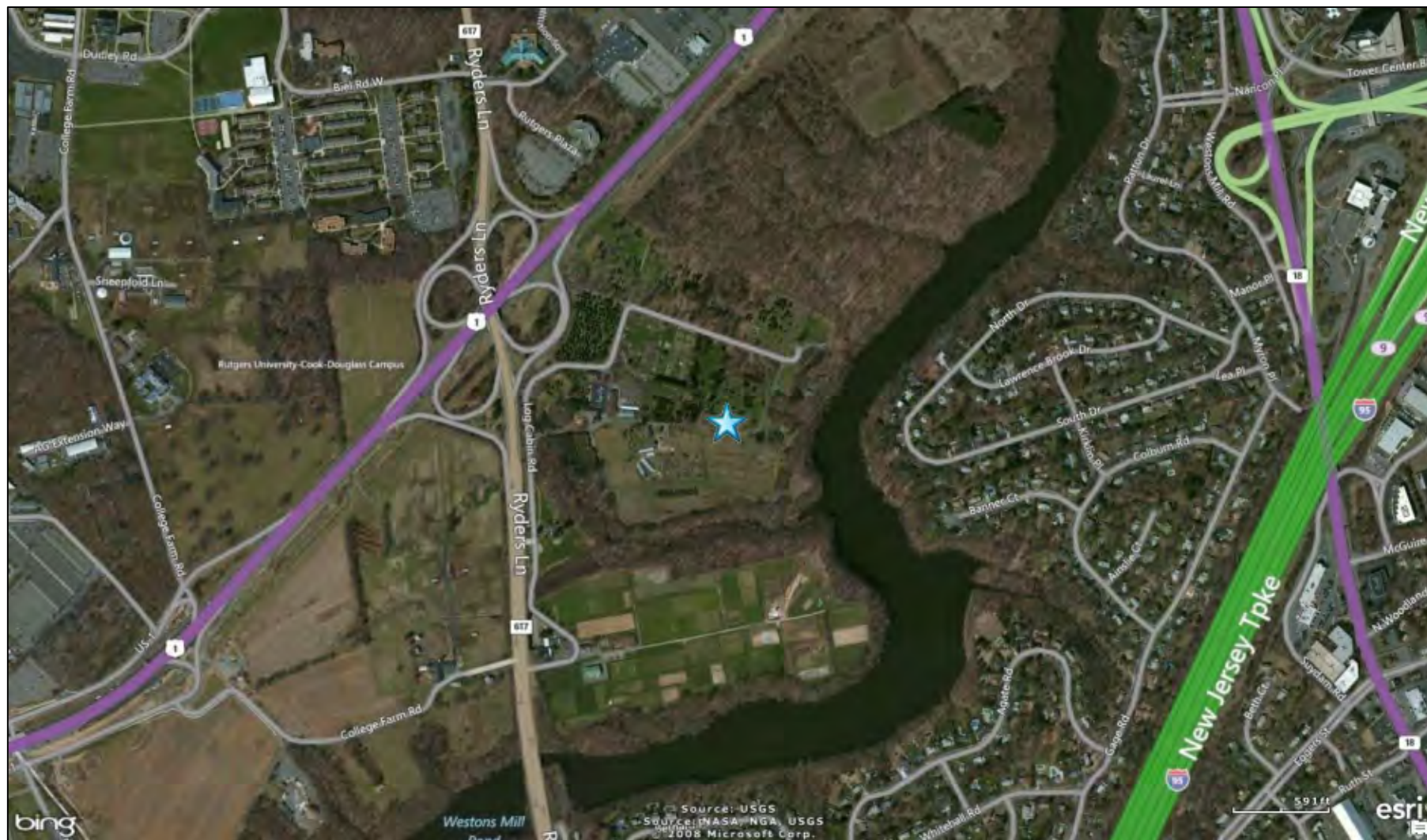


Figure 20-7. NEI Point Sources Located Within 10 Miles of ELNJ and NBNJ

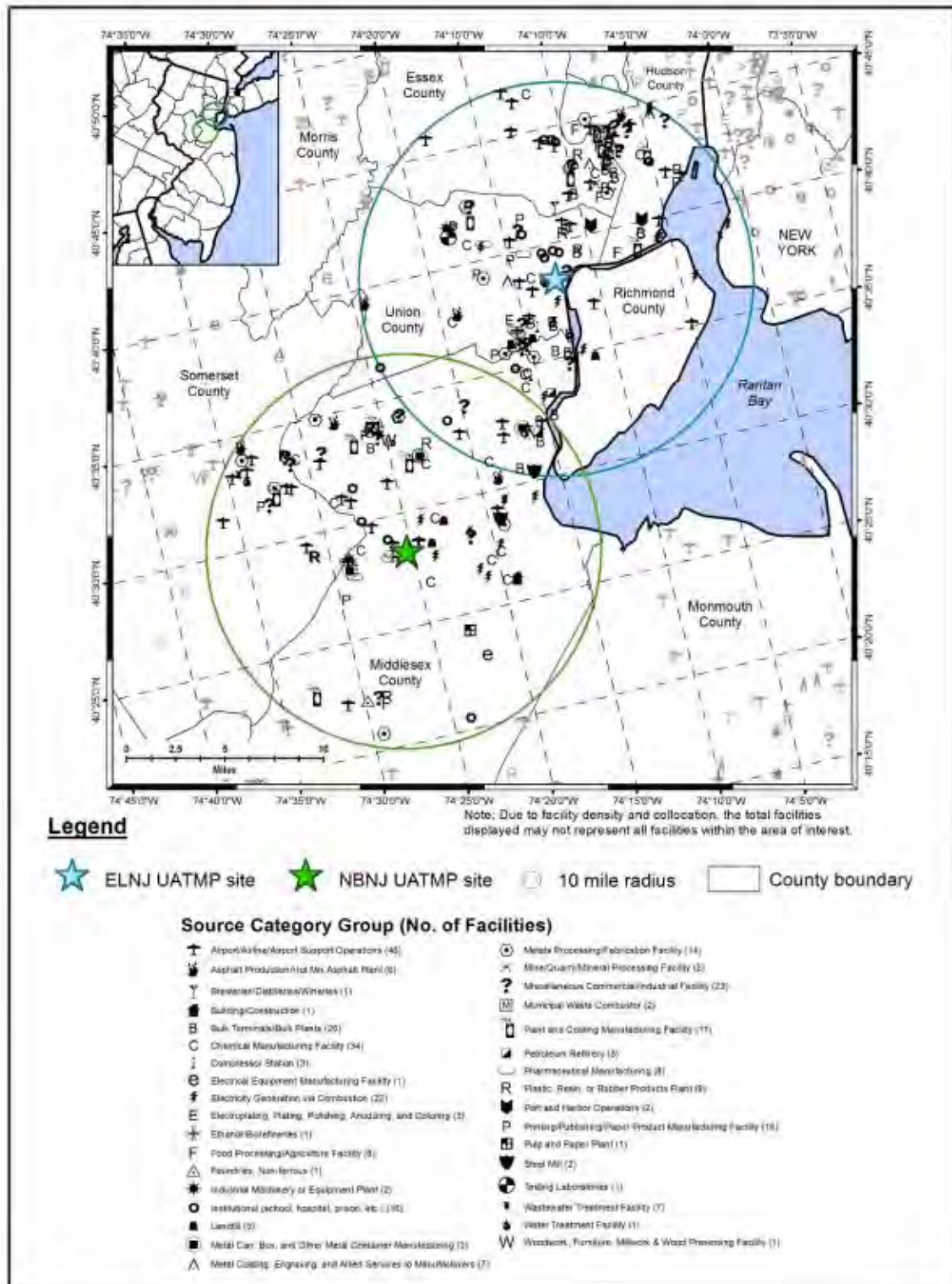


Table 20-1. Geographical Information for the New Jersey Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
CSNJ	34-007-0002	Camden	Camden	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	39.934446, -75.125291	Industrial	Urban/City Center	CO, IMPROVE Speciation, Meteorological parameters, NO, NO ₂ , NO _x , O ₃ , PM _{2.5} , SO ₂ , PM _{2.5} Speciation.
CHNJ	34-027-3001	Chester	Morris	New York-Newark-Jersey City, NY-NJ-PA	40.787628, -74.676301	Agricultural	Rural	SO ₂ , NO, NO ₂ , O ₃ , Meteorological parameters, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
ELNJ	34-039-0004	Elizabeth	Union	New York-Newark-Jersey City, NY-NJ-PA	40.64144, -74.208365	Industrial	Suburban	CO, SO ₂ , NO ₂ , Meteorological parameters, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
NBNJ	34-023-0006	North Brunswick	Middlesex	New York-Newark-Jersey City, NY-NJ-PA	40.472825, -74.422403	Agricultural	Rural	Meteorological parameters, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

The CSNJ monitoring site is located just outside Philadelphia, across the state line, in the city of Camden in southwest New Jersey. The monitoring site is in an industrial area a few blocks east of the Delaware River, as shown in Figure 20-1. Residential areas are located to the east between the site and I-676. Figure 20-2 shows that the large number of point sources located within 10 miles of CSNJ are involved in a variety of industries. The source categories with the largest number of facilities include institutions (such as schools, hospitals, and prisons); airports and airport support operations, which include airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; printing, publishing, and paper product manufacturing; chemical manufacturing; and bulk terminals and bulk plants. The sources closest to CSNJ include a metals processing and fabrication facility; a mine/quarry/minerals processing facility; an airport/airport operations facility; and a metal can, box, and other container manufacturing facility.

CHNJ is located in northern New Jersey, in the town of Chester, west of the New York City metropolitan area. Figure 20-3 shows that CHNJ is located in an open area near Building 1 of the Department of Public Works off Routes 513 and 510. The surrounding area is rural and agricultural with a rolling topography, but surrounded by small neighborhoods. Two schools are located on the other side of Route 510 to the south-southwest of CHNJ. Although the location is considered part of the New York City metro area, the site's location is outside most of the urbanized areas. Figure 20-4 shows that few sources are located within a few miles of CHNJ. The source category with the greatest number of emissions sources within 10 miles of CHNJ is the airport source category. The sources closest to CHNJ include a privately owned heliport to the south and a wood work, furniture, millwork, and wood preserving facility to the west.

ELNJ is located in the city of Elizabeth, which lies just south of Newark and west of Newark Bay and Staten Island, New York. As Figure 20-5 shows, the monitoring site is located near the toll plaza just off Exit 13 of the New Jersey Turnpike (I-95). Interstate-278 intersects the Turnpike here as well. The surrounding area is highly industrialized, with an oil refinery located just southwest of the site. Additional industry is located to the southwest and west, as well as on the east side of the Turnpike, while residential neighborhoods are located to the north and northwest of ELNJ.

NBNJ is located in North Brunswick, approximately 16 miles southwest of Elizabeth. The monitoring site is located on the property of Rutgers University's Cook-Douglass campus, on a horticultural farm. The surrounding area is agricultural and rural, although residential neighborhoods are located to the east, across a branch of the Raritan River, as shown in Figure 20-6. County Road 617 (Ryders Lane) and US-1 intersect just west of the site and I-95 runs northeast-southwest less than 1 mile east of the site, part of which can be seen on the right hand side of Figure 20-6.

Figure 20-7 shows that the outer portions of the 10-mile boundaries for ELNJ and NBNJ intersect; these sites are located approximately 17 miles apart. Many emissions sources surround these two sites. The majority of the emissions sources are located in northern Middlesex County and northeastward toward New York City and northern New Jersey. The source categories with the greatest number of emissions sources in the vicinity of these sites include airport operations, chemical manufacturing, bulk terminals and bulk plants, and electricity generation via combustion. The emissions sources in closest proximity to the ELNJ monitoring site are in the wastewater treatment, chemical manufacturing, bulk terminals/bulk plant, petroleum refining, and electricity generation via combustion source categories. The emissions sources in closest proximity to the NBNJ monitoring site are involved in plastic, resin, or rubber products manufacturing, airport and airport support operations, and pharmaceutical manufacturing.

Table 20-2 presents additional site-characterizing information, including indicators of mobile source activity, for the New Jersey monitoring sites. Table 20-2 includes a county-level population for each site. County-level vehicle registration data for Camden, Union, Morris, and Middlesex Counties were not available from the State of New Jersey. Thus, state-level vehicle registration, which was obtained from the Federal Highway Administration (FHWA), was allocated to the county level using the county-level proportion of the state population from the U.S. Census Bureau. Table 20-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 20-2 presents the county-level daily VMT for the four New Jersey counties.

Table 20-2. Population, Motor Vehicle, and Traffic Information for the New Jersey Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
CSNJ	Camden	512,854	458,294	3,231	S 2nd St. south of Walnut St.	10,753,157
CHNJ	Morris	499,397	443,969	11,215	Mendham Rd (510/24) east of Fox Chase Rd	14,622,523
ELNJ	Union	548,256	485,427	250,000	Between Exits 13 & 13A on I-95	12,081,401
NBNJ	Middlesex	828,919	734,425	110,653	US-1 west of 617	21,634,307

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect ratios based on 2012 state-level vehicle registration data from the FHWA and the 2012 county-level proportion of the state population data (FHWA, 2014 and Census Bureau, 2013c)

³AADT for ELNJ reflects 2006 data from NJ Department of Treasury; AADT reflect 2009 data for NBNJ and 2012 data for CSNJ and CHNJ from the NJ DOT (NJ DOTr, 2008 and NJ DOT, 2014)

⁴County-level VMT reflects 2012 data (NJ DOT, 2012)

Observations from Table 20-2 include the following:

- Middlesex County, where NBNJ is located, has the highest county-level population for the New Jersey sites while Morris County, where CHNJ is located, has the least (although the populations for the counties other than Middlesex are not that different). Compared to NMP monitoring sites in other locations, the county-level populations are in the middle of the range, ranking 17th, then 25th through 27th.
- The estimated county-level vehicle registration is also highest for NBNJ and least for CHNJ (although the vehicle registrations for the counties other than Middlesex are not that different). The county-level registration estimates for these sites have similar rankings as the county-level populations among NMP sites.
- ELNJ and NBNJ experience a significantly higher traffic volume than CHNJ and CSNJ. Traffic data for ELNJ are provided for I-95, between Exit 13 and 13A; this is the second highest traffic volume among all NMP sites (behind only LBHCA). Traffic data for CHNJ are provided for Route 510, east of Fox Chase Road; traffic data for NBNJ are provided for US-1, west of State Road 617 (Ryders Lane); and traffic data for CSNJ are provided for South 2nd Street, south of Walnut Street.
- The daily VMT is highest for Middlesex County (NBNJ) and lowest for Camden County (CSNJ). The VMT for Middlesex County ranks 15th compared to other counties with NMP sites while the other New Jersey counties are in the middle of the range.

20.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in New Jersey on sample days, as well as over the course of the year.

20.2.1 Climate Summary

Frontal systems push across the state of New Jersey regularly, producing variable weather conditions. The state's proximity to the Atlantic Ocean has a moderating effect on temperatures. Summers along the coast tend to be cooler than areas farther inland, while winters tend to be warmer. Large urban areas within the state experience the urban heat island effect, in which urban areas retain more heat than outlying areas. New Jersey's Mid-Atlantic location also allows for ample annual precipitation, generally between 3 inches and 4 inches per month, and relatively high humidity. Temperatures tend to be higher and precipitation lower in the southwest part of the state than the northern and coastal portions of the state. A southwesterly wind is most common in the summer and a northwesterly wind is typical in the winter. Winds from the west and northwest result in air masses that dry out, stabilize, and warm as they move eastward from higher elevations to sea level (Wood, 2004; Rutgers, 2015).

20.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the New Jersey monitoring sites (NCDC, 2013), as described in Section 3.4.2. The closest weather stations are located at Philadelphia International Airport (near CSNJ), Somerville-Somerset Airport (near CHNJ and NBNJ), and Newark International Airport (near ELNJ), WBANs 13738, 54785, and 14734, respectively. Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 20-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 20-3. Average Meteorological Conditions near the New Jersey Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Camden, New Jersey - CSNJ									
Philadelphia Intl Airport 13738 (39.87, -75.23)	7.2 miles	Sample Days (66)	64.5 ± 4.7	56.4 ± 4.4	42.1 ± 4.8	49.6 ± 4.1	61.5 ± 3.1	1018.6 ± 1.7	7.5 ± 0.7
	231° (SW)	2013	64.0 ± 1.9	56.3 ± 1.8	42.3 ± 2.0	49.7 ± 1.7	62.2 ± 1.4	1018.2 ± 0.7	7.5 ± 0.3
Chester, New Jersey - CHNJ									
Somerville, New Jersey/Somerset Airport 54785 (40.62, -74.67)	11.3 miles	Sample Days (61)	63.1 ± 5.0	52.6 ± 4.5	41.9 ± 5.1	47.7 ± 4.4	70.3 ± 3.4	1017.7 ± 1.7	3.4 ± 0.7
	178° (S)	2013	62.6 ± 1.9	52.4 ± 1.8	41.9 ± 2.0	47.6 ± 1.7	70.8 ± 1.4	1017.2 ± 0.7	3.2 ± 0.2
Elizabeth, New Jersey - ELNJ									
Newark International Airport 14734 (40.68, -74.17)	3.5 miles	Sample Days (61)	63.5 ± 5.0	55.5 ± 4.7	41.8 ± 5.0	49.0 ± 4.3	62.9 ± 3.6	1017.6 ± 1.6	7.8 ± 0.8
	36° (NE)	2013	62.9 ± 1.9	55.4 ± 1.8	41.7 ± 2.0	49.0 ± 1.7	63.1 ± 1.5	1017.5 ± 0.7	8.0 ± 0.3
North Brunswick, New Jersey - NBNJ									
Somerville, New Jersey/Somerset Airport 54785 (40.62, -74.67)	16.7 miles	Sample Days (66)	63.0 ± 4.6	52.3 ± 4.2	42.0 ± 4.6	47.5 ± 4.0	71.1 ± 3.0	1017.3 ± 1.8	3.3 ± 0.6
	309° (NW)	2013	62.6 ± 1.9	52.4 ± 1.8	41.9 ± 2.0	47.6 ± 1.7	70.8 ± 1.4	1017.2 ± 0.7	3.2 ± 0.2

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 20-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 20-3 is the 95 percent confidence interval for each parameter. As shown in Table 20-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year near CSNJ, CHNJ, ELNJ, and NBNJ. The largest difference between a sample day and a full-year average is for relative humidity at CSNJ, although the difference is less than 1 percent and not statistically significant.

20.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations nearest the New Jersey sites, as presented in Section 20.2.2, were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

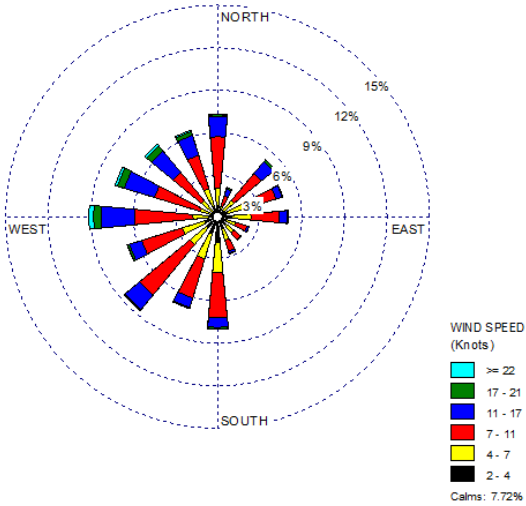
Figure 20-8 presents a map showing the distance between the weather station and CSNJ, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 20-8 also presents three different wind roses for the CSNJ monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 20-9 through 20-11 present the distance maps and wind roses for CHNJ, ELNJ and NBNJ, respectively.

Figure 20-8. Wind Roses for the Philadelphia International Airport Weather Station near CSNJ

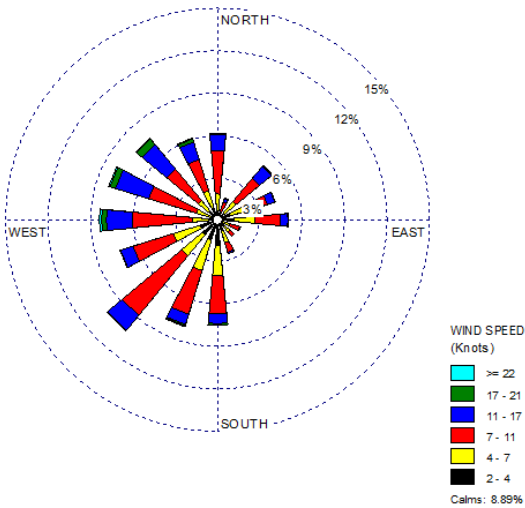
Location of CSNJ and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

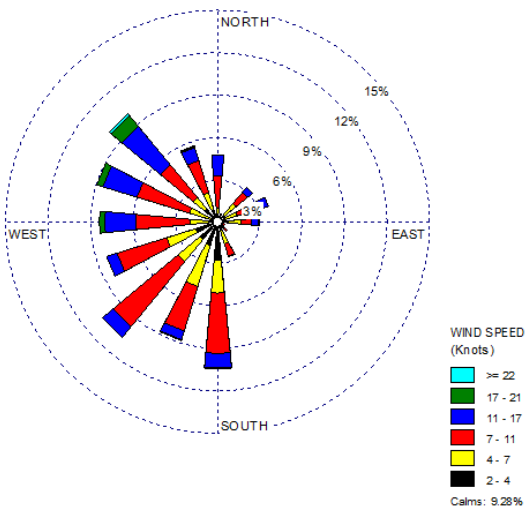
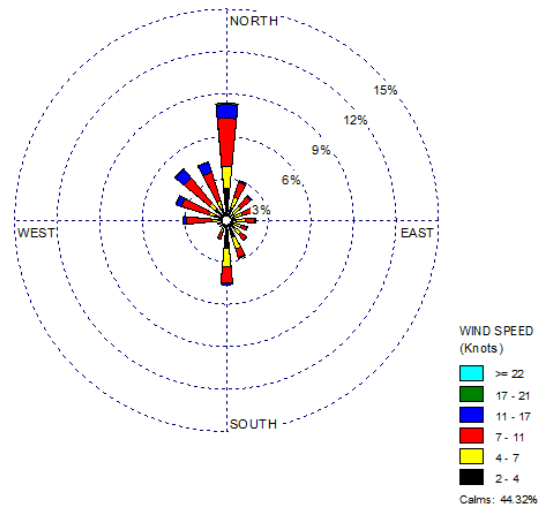


Figure 20-9. Wind Roses for the Somerville-Somerset Airport Weather Station near CHNJ

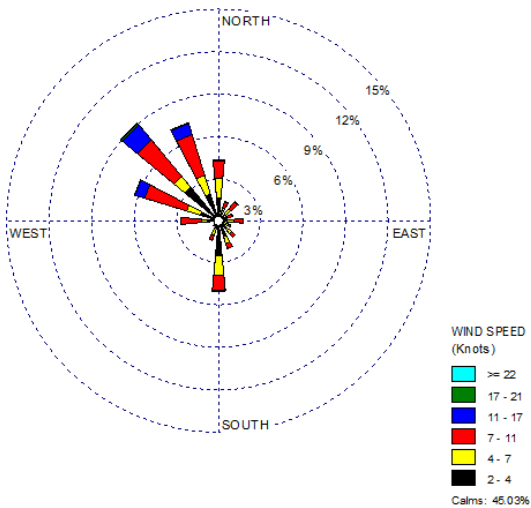
Location of CHNJ and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

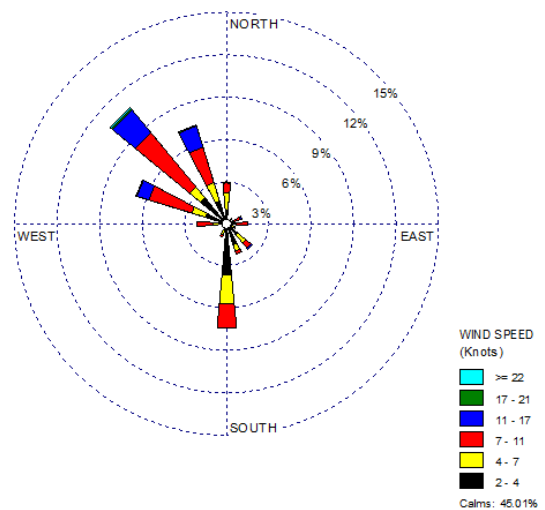
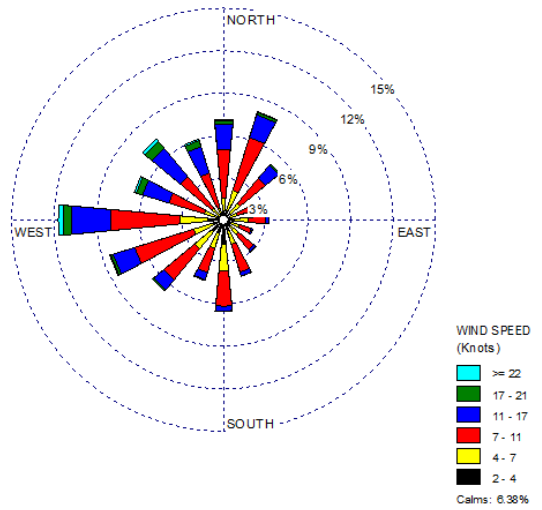


Figure 20-10. Wind Roses for the Newark International Airport Weather Station near ELNJ

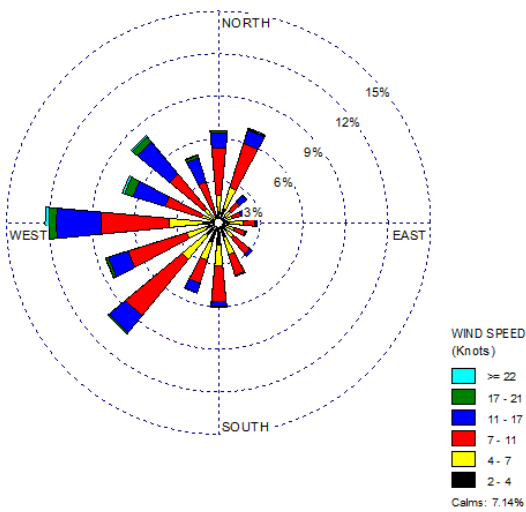
Location of ELNJ and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

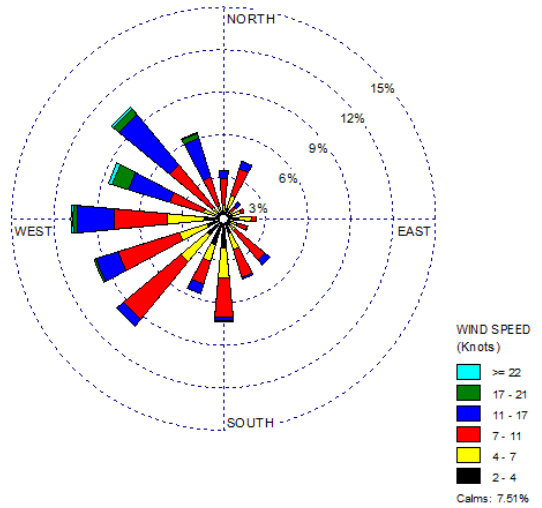
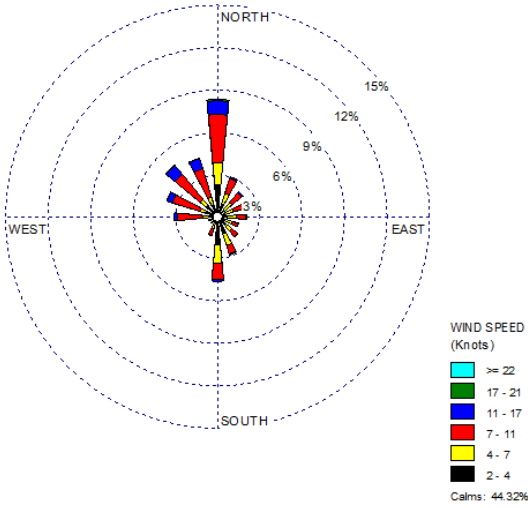


Figure 20-11. Wind Roses for the Somerville-Somerset Airport Weather Station near NBNJ

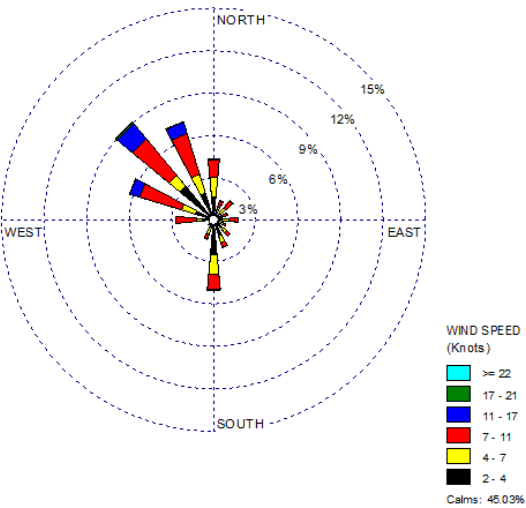
Location of NBNJ and Weather Station



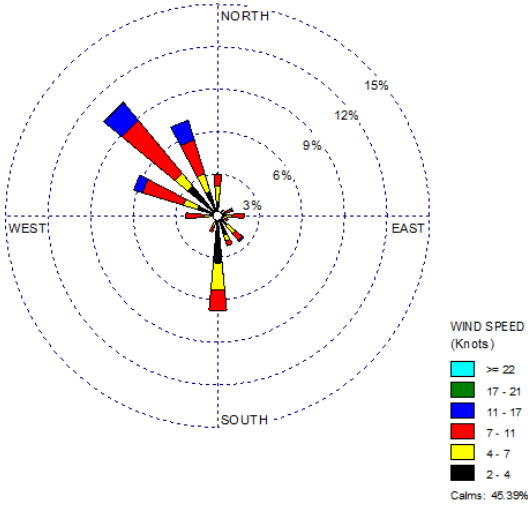
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 20-8 for CSNJ include the following:

- The Philadelphia International Airport weather station is located 7.2 miles southwest of CSNJ. Both the site and the weather station are located near the Delaware River, which separates Pennsylvania from New Jersey, and runs along the east and south sides of Philadelphia.
- The historical wind rose shows that winds from a variety of directions were observed near CSNJ, with westerly and southwesterly winds observed the most and north-northeasterly winds and winds from the southeast quadrant observed the least. Calm winds (those less than or equal to 2 knots) account for nearly 8 percent of observations. The strongest winds were most often observed with westerly to northwesterly winds.
- The wind patterns shown on the 2013 wind rose are similar to the historical wind patterns, indicating that wind conditions observed throughout 2013 were similar to those observed historically, although a slightly higher percentage of calm winds were observed.
- The sample day wind rose shows that fewer winds with an easterly component were observed on sample days; thus, an even higher percentage of winds with a westerly component were observed. Observations of winds from the northwest and south increased the most, from about 7.5 percent to 10 percent on sample days. The percentage of calm winds is also slightly higher on the sample day wind rose.

Observations from Figures 20-9 and 20-11 for CHNJ and NBNJ include the following:

- The weather station at Somerville/Somerset Airport is the closest weather station to both CHNJ and NBNJ. The Somerville/Somerset Airport weather station is located 11.3 miles south of CHNJ and 16.7 miles northwest of NBNJ.
- The historical and full-year wind roses for CHNJ are identical to the historical and full-year wind roses for NBNJ because the data are from the same weather station.
- The historical wind roses for these sites show that calm winds account for nearly 45 percent of observations. For wind speeds greater than 2 knots, northerly winds were observed most frequently, accounting for nearly 9 percent of the observations, while winds from the southwest quadrant were rarely observed.
- Calm winds account for 45 percent of the wind observations in 2013. Winds from the west-northwest to north account for another one-quarter of wind observations. With the exception of southerly winds, which account for roughly 5 percent of the observations, winds from the other directions were observed infrequently.
- The sample day wind roses for CHNJ and NBNJ are similar to the full-year wind roses. However, the number of northerly wind observations was less on sample days, while southerly and northwesterly winds were observed more often.

- While the 2013 wind roses do exhibit the same prevalence for calm winds as the historical wind rose, they do not exhibit the same northerly predominance for wind speeds greater than 2 knots. Instead, there is a higher percentage of wind observations from the northwest quadrant. Similar observations have been made in NMP reports going back to 2009.

Observations from Figure 20-10 for ELNJ include the following:

- The Newark International Airport weather station is located 3.5 miles northeast of ELNJ. Both the site and the weather station are located in close proximity to the New Jersey Turnpike.
- The historical wind rose shows that winds from a variety of directions were observed near ELNJ, although winds from the east-northeast to southeast were observed infrequently. Calm winds account for 6 percent of observations. The strongest winds were associated with westerly to northwesterly winds.
- The wind patterns shown on the 2013 wind rose are similar to the historical wind patterns, indicating that wind conditions observed throughout 2013 were similar to those observed historically. However, a higher percentage of southwesterly winds was observed in 2013 (about 10 percent compared to less than 7 percent historically), while a lower percentage of northeasterly winds was observed (less than 3 percent in 2013 compared to nearly 7 percent historically).
- The sample day wind rose shows that winds from the southeast to south as well as those from the western quadrants accounted for a higher percentage of wind observations on sample days while fewer wind observations from the north to east were observed.

20.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each New Jersey monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 20-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 20-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. VOCs and carbonyl compounds were sampled for at all four New Jersey sites.

Table 20-4. Risk-Based Screening Results for the New Jersey Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Camden, New Jersey - CSNJ						
Acetaldehyde	0.45	59	59	100.00	14.68	14.68
Formaldehyde	0.077	59	59	100.00	14.68	29.35
Benzene	0.13	57	57	100.00	14.18	43.53
Carbon Tetrachloride	0.17	57	57	100.00	14.18	57.71
1,3-Butadiene	0.03	56	56	100.00	13.93	71.64
1,2-Dichloroethane	0.038	53	53	100.00	13.18	84.83
Hexachloro-1,3-butadiene	0.045	15	15	100.00	3.73	88.56
Ethylbenzene	0.4	14	57	24.56	3.48	92.04
Propionaldehyde	0.8	11	59	18.64	2.74	94.78
Bromomethane	0.5	7	53	13.21	1.74	96.52
<i>p</i> -Dichlorobenzene	0.091	4	31	12.90	1.00	97.51
Trichloroethylene	0.2	4	23	17.39	1.00	98.51
Methyl <i>tert</i> -Butyl Ether	3.8	3	55	5.45	0.75	99.25
1,2-Dibromoethane	0.0017	1	1	100.00	0.25	99.50
1,1,2-Trichloroethane	0.0625	1	1	100.00	0.25	99.75
Vinyl chloride	0.11	1	12	8.33	0.25	100.00
Total		402	648	62.04		
Chester, New Jersey - CHNJ						
Acetaldehyde	0.45	61	61	100.00	16.80	16.80
Formaldehyde	0.077	61	61	100.00	16.80	33.61
Benzene	0.13	60	61	98.36	16.53	50.14
Carbon Tetrachloride	0.17	60	61	98.36	16.53	66.67
1,2-Dichloroethane	0.038	54	54	100.00	14.88	81.54
1,3-Butadiene	0.03	40	46	86.96	11.02	92.56
Hexachloro-1,3-butadiene	0.045	14	14	100.00	3.86	96.42
Methyl <i>tert</i> -Butyl Ether	3.8	12	59	20.34	3.31	99.72
Ethylbenzene	0.4	1	61	1.64	0.28	100.00
Total		363	478	75.94		

Table 20-4. Risk-Based Screening Results for the New Jersey Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	0.45	61	61	100.00	15.10	15.10
Benzene	0.13	61	61	100.00	15.10	30.20
1,3-Butadiene	0.03	61	61	100.00	15.10	45.30
Carbon Tetrachloride	0.17	61	61	100.00	15.10	60.40
Formaldehyde	0.077	61	61	100.00	15.10	75.50
1,2-Dichloroethane	0.038	47	47	100.00	11.63	87.13
Ethylbenzene	0.4	31	61	50.82	7.67	94.80
Hexachloro-1,3-butadiene	0.045	11	13	84.62	2.72	97.52
Propionaldehyde	0.8	7	61	11.48	1.73	99.26
<i>p</i> -Dichlorobenzene	0.091	2	29	6.90	0.50	99.75
Trichloroethylene	0.2	1	18	5.56	0.25	100.00
Total		404	534	75.66		
North Brunswick, New Jersey - NBNJ						
Acetaldehyde	0.45	62	62	100.00	16.23	16.23
Formaldehyde	0.077	62	62	100.00	16.23	32.46
Benzene	0.13	61	61	100.00	15.97	48.43
Carbon Tetrachloride	0.17	61	61	100.00	15.97	64.40
1,2-Dichloroethane	0.038	59	59	100.00	15.45	79.84
1,3-Butadiene	0.03	57	58	98.28	14.92	94.76
Hexachloro-1,3-butadiene	0.045	14	16	87.50	3.66	98.43
Ethylbenzene	0.4	3	61	4.92	0.79	99.21
1,2-Dibromoethane	0.0017	1	1	100.00	0.26	99.48
<i>p</i> -Dichlorobenzene	0.091	1	28	3.57	0.26	99.74
Trichloroethylene	0.2	1	12	8.33	0.26	100.00
Total		382	481	79.42		

Observations from Table 20-4 include the following:

- Sixteen pollutants failed at least one screen for CSNJ; 62 percent of concentrations for these 16 pollutants were greater than their associated risk screening value (or failed screens).
- Ten pollutants contributed to 95 percent of failed screens for CSNJ and therefore were identified as pollutants of interest for this site. These 10 include three carbonyl compounds and seven VOCs.
- Nine pollutants failed at least one screen for CHNJ; 76 percent of concentrations for these nine pollutants were greater than their associated risk screening value (or failed screens).

- Seven pollutants contributed to 95 percent of failed screens for CHNJ and therefore were identified as pollutants of interest for this site. These seven include two carbonyl compounds and five VOCs.
- Eleven pollutants failed at least one screen for ELNJ, with nearly 76 percent of concentrations for these 11 pollutants greater than their associated risk screening value.
- Eight pollutants contributed to 95 percent of failed screens for ELNJ and therefore were identified as pollutants of interest for this site. These eight include two carbonyl compounds and six VOCs.
- Eleven pollutants failed at least one screen for NBNJ, with 79 percent of concentrations for these 11 pollutants greater than their associated risk screening value.
- Seven pollutants contributed to 95 percent of failed screens for NBNJ and therefore were identified as pollutants of interest for this site. These seven include two carbonyl compounds and five VOCs.
- The New Jersey sites have seven pollutants of interest in common: acetaldehyde, formaldehyde, benzene, carbon tetrachloride, 1,3-butadiene, 1,2-dichloroethane, and hexachloro-1,3-butadiene.
- CSNJ is the only NMP site with bromomethane as a site-specific pollutant of interest; CSNJ is one of only two NMP sites with propionaldehyde as a site-specific pollutant of interest.

20.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the New Jersey monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at the New Jersey monitoring sites are provided in Appendices J and L.

20.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each New Jersey site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the New Jersey monitoring sites are presented in Table 20-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 20-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the New Jersey Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Camden, New Jersey - CSNJ						
Acetaldehyde	59/59	2.15 ± 0.46	3.96 ± 0.76	3.06 ± 0.48	1.86 ± 0.23	2.78 ± 0.33
Benzene	57/57	0.99 ± 0.23	0.88 ± 0.24	0.75 ± 0.17	0.78 ± 0.18	0.85 ± 0.10
Bromomethane	53/57	0.45 ± 0.45	0.52 ± 0.72	0.11 ± 0.08	0.91 ± 1.79	0.52 ± 0.50
1,3-Butadiene	56/57	0.10 ± 0.02	0.09 ± 0.02	0.09 ± 0.03	0.11 ± 0.03	0.10 ± 0.01
Carbon Tetrachloride	57/57	0.55 ± 0.05	0.62 ± 0.06	0.67 ± 0.03	0.60 ± 0.04	0.61 ± 0.03
1,2-Dichloroethane	53/57	0.10 ± 0.02	0.11 ± 0.01	0.06 ± 0.02	0.08 ± 0.02	0.09 ± 0.01
Ethylbenzene	57/57	0.28 ± 0.08	0.29 ± 0.07	0.36 ± 0.06	0.30 ± 0.11	0.31 ± 0.04
Formaldehyde	59/59	3.34 ± 0.80	6.69 ± 1.07	6.29 ± 1.06	3.44 ± 0.36	4.96 ± 0.59
Hexachloro-1,3-butadiene	15/57	0.01 ± 0.01	0.02 ± 0.02	0.01 ± 0.02	0.04 ± 0.03	0.02 ± 0.01
Propionaldehyde	59/59	0.46 ± 0.09	0.88 ± 0.16	0.67 ± 0.11	0.36 ± 0.04	0.60 ± 0.07
Chester, New Jersey - CHNJ						
Acetaldehyde	61/61	1.29 ± 0.39	1.58 ± 0.39	1.18 ± 0.21	1.18 ± 0.23	1.31 ± 0.15
Benzene	61/61	0.60 ± 0.09	0.39 ± 0.06	0.57 ± 0.36	0.42 ± 0.07	0.49 ± 0.09
1,3-Butadiene	46/61	0.03 ± 0.01	0.04 ± 0.02	0.03 ± 0.02	0.05 ± 0.02	0.04 ± 0.01
Carbon Tetrachloride	61/61	0.60 ± 0.04	0.59 ± 0.08	0.64 ± 0.04	0.62 ± 0.03	0.61 ± 0.02
1,2-Dichloroethane	54/61	0.09 ± 0.01	0.09 ± 0.02	0.06 ± 0.02	0.06 ± 0.02	0.08 ± 0.01
Formaldehyde	61/61	1.09 ± 0.32	2.88 ± 0.56	3.22 ± 0.66	1.41 ± 0.46	2.14 ± 0.34
Hexachloro-1,3-butadiene	14/61	0.01 ± 0.02	0.02 ± 0.02	0.01 ± 0.01	0.04 ± 0.03	0.02 ± 0.01

Table 20-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the New Jersey Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	61/61	1.89 ± 0.32	3.26 ± 0.65	3.02 ± 0.40	2.26 ± 0.41	2.60 ± 0.26
Benzene	61/61	0.84 ± 0.17	0.80 ± 0.09	0.76 ± 0.11	0.82 ± 0.17	0.81 ± 0.07
1,3-Butadiene	61/61	0.11 ± 0.03	0.11 ± 0.02	0.10 ± 0.02	0.13 ± 0.03	0.11 ± 0.01
Carbon Tetrachloride	61/61	0.60 ± 0.04	0.64 ± 0.05	0.66 ± 0.03	0.61 ± 0.03	0.63 ± 0.02
1,2-Dichloroethane	47/61	0.09 ± 0.01	0.10 ± 0.03	0.05 ± 0.02	0.06 ± 0.03	0.07 ± 0.01
Ethylbenzene	61/61	0.25 ± 0.07	0.54 ± 0.10	0.51 ± 0.10	0.43 ± 0.13	0.43 ± 0.06
Formaldehyde	61/61	2.89 ± 0.35	6.87 ± 1.83	6.35 ± 0.93	3.56 ± 0.69	4.90 ± 0.67
Hexachloro-1,3-butadiene	13/61	<0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.04 ± 0.02	0.02 ± 0.01
North Brunswick, New Jersey - NBNJ						
Acetaldehyde	62/62	1.08 ± 0.16	1.77 ± 0.31	1.98 ± 0.28	1.73 ± 0.26	1.66 ± 0.15
Benzene	61/61	0.82 ± 0.11	0.63 ± 0.06	0.52 ± 0.06	0.64 ± 0.09	0.65 ± 0.05
1,3-Butadiene	58/61	0.08 ± 0.02	0.06 ± 0.01	0.06 ± 0.01	0.08 ± 0.01	0.07 ± 0.01
Carbon Tetrachloride	61/61	0.57 ± 0.04	0.64 ± 0.03	0.65 ± 0.03	0.61 ± 0.02	0.62 ± 0.02
1,2-Dichloroethane	59/61	0.09 ± 0.01	0.10 ± 0.01	0.06 ± 0.01	0.09 ± 0.01	0.09 ± 0.01
Formaldehyde	62/62	1.17 ± 0.25	2.38 ± 0.51	3.47 ± 0.70	1.91 ± 0.29	2.24 ± 0.30
Hexachloro-1,3-butadiene	16/61	0.03 ± 0.03	0.01 ± 0.02	<0.01 ± 0.01	0.05 ± 0.03	0.02 ± 0.01

Observations for CSNJ from Table 20-5 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde ($4.96 \pm 0.59 \mu\text{g}/\text{m}^3$) and acetaldehyde ($2.78 \pm 0.33 \mu\text{g}/\text{m}^3$). These are the only two pollutants with annual average concentrations greater than $1 \mu\text{g}/\text{m}^3$. Of the VOCs, benzene has the highest annual average concentration ($0.85 \pm 0.10 \mu\text{g}/\text{m}^3$).
- Concentrations of formaldehyde were highest during the second and third quarters of 2013, based on the quarterly averages shown, and nearly double the magnitude of the first and fourth quarter averages. A review of the data shows that formaldehyde concentrations measured at CSNJ range from $1.44 \mu\text{g}/\text{m}^3$ to $11.6 \mu\text{g}/\text{m}^3$. All but two of the 25 highest formaldehyde concentrations (those greater than $5 \mu\text{g}/\text{m}^3$) were

measured between April and September (with the other two measured in late March). Further, the 11 lowest concentrations (those less than $3 \mu\text{g}/\text{m}^3$) were measured between January and March or November and December. This supports the seasonal tendency of formaldehyde discussed in Section 4.4.2. Quarterly average concentrations of acetaldehyde and propionaldehyde exhibit a similar tendency.

- The quarterly average concentrations of bromomethane each have relatively large confidence intervals compared to the averages themselves, indicating that concentrations of bromomethane measured at CSNJ are highly variable. A review of the data shows that concentrations of bromomethane measured at CSNJ range from $0.04 \mu\text{g}/\text{m}^3$ to $13.1 \mu\text{g}/\text{m}^3$, including four non-detects, with a median concentration of $0.07 \mu\text{g}/\text{m}^3$. This site has the six highest bromomethane concentrations measured across the program, including all five measurements were greater than $1 \mu\text{g}/\text{m}^3$.

Observations for CHNJ from Table 20-5 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde ($2.14 \pm 0.34 \mu\text{g}/\text{m}^3$) and acetaldehyde ($1.31 \pm 0.15 \mu\text{g}/\text{m}^3$). These are the only two pollutants with annual average concentrations greater than $1 \mu\text{g}/\text{m}^3$. Of the VOCs, carbon tetrachloride has the highest annual average concentration ($0.61 \pm 0.02 \mu\text{g}/\text{m}^3$).
- Similar to CSNJ, concentrations of formaldehyde were highest during the second and third quarters of 2013 at CHNJ, based on the quarterly averages shown, although considerably less than those measured at CSNJ. A review of the data shows that formaldehyde concentrations measured at CHNJ range from $0.48 \mu\text{g}/\text{m}^3$ to $5.34 \mu\text{g}/\text{m}^3$, with the five highest concentrations all measured in June and July and the 10 highest concentrations all measured between April and September. Conversely, the lowest 17 formaldehyde concentrations (those less than $1 \mu\text{g}/\text{m}^3$) were measured between January and March or October and December. Quarterly average concentrations of acetaldehyde do not exhibit a similar tendency as the highest concentrations were measured between January and April and at least one of the 10 highest concentrations was measured in every calendar quarter.
- The quarterly average concentrations of benzene are fairly similar to each other, but the confidence interval for the third quarter average is four to six times higher than the other confidence intervals. A review of the data shows that the two highest benzene concentrations were both measured during the third quarter and are the only two benzene concentrations greater than $1 \mu\text{g}/\text{m}^3$ measured at CHNJ ($2.88 \mu\text{g}/\text{m}^3$ measured on September 13, 2013 and $1.09 \mu\text{g}/\text{m}^3$ measured on July 3, 2013). The next highest 13 concentrations were all measured during the first or fourth quarters of the year. Benzene concentrations measured during the third quarter span an order of magnitude, ranging from $0.23 \mu\text{g}/\text{m}^3$ to $2.88 \mu\text{g}/\text{m}^3$, with a median concentration of $0.35 \mu\text{g}/\text{m}^3$. This range is greater than the range of concentrations measured in each of the other quarters yet this quarter has the lowest median benzene concentration. A similar observation regarding third quarter benzene concentrations was made in the 2012 NMP report.

Observations for ELNJ from Table 20-5 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde ($4.90 \pm 0.67 \mu\text{g}/\text{m}^3$) and acetaldehyde ($2.60 \pm 0.26 \mu\text{g}/\text{m}^3$). These are the only two pollutants with annual average concentrations greater than $1 \mu\text{g}/\text{m}^3$. Of the VOCs, benzene has the highest annual average concentration ($0.81 \pm 0.07 \mu\text{g}/\text{m}^3$).
- Similar to CSNJ and CHNJ, concentrations of formaldehyde measured at ELNJ were higher during the warmer months of the year, as indicated by the second and third quarter average concentrations. A review of the data shows that formaldehyde concentrations measured at ELNJ range from $1.33 \mu\text{g}/\text{m}^3$ to $15.9 \mu\text{g}/\text{m}^3$. The maximum concentration was measured on May 10, 2013 and is tied for the fifth highest formaldehyde concentration measured across the program. All 11 highest formaldehyde concentrations (those greater than $7 \mu\text{g}/\text{m}^3$) were measured at ELNJ between April and August while all but one of the 18 formaldehyde concentrations less than $3 \mu\text{g}/\text{m}^3$ were measured between January and March or November and December. Quarterly average concentrations of acetaldehyde exhibit a similar tendency but the differences are not statistically significant.
- Concentrations of ethylbenzene were lowest during the first quarter of 2013, as indicated by the quarterly averages of this pollutant shown in Table 20-5. Eight of the 10 ethylbenzene concentrations less than or equal to $2 \mu\text{g}/\text{m}^3$ were measured during the first quarter of 2013. By contrast, only one concentration greater than $5 \mu\text{g}/\text{m}^3$ was measured at ELNJ during the first quarter compared to between five and eight during the other calendar quarters.

Observations for NBNJ from Table 20-5 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde ($2.24 \pm 0.30 \mu\text{g}/\text{m}^3$) and acetaldehyde ($1.66 \pm 0.15 \mu\text{g}/\text{m}^3$). These are the only two pollutants with annual average concentrations greater than $1 \mu\text{g}/\text{m}^3$. Of the VOCs, benzene has the highest annual average concentration ($0.65 \pm 0.05 \mu\text{g}/\text{m}^3$), although the annual average for carbon tetrachloride is similar ($0.62 \pm 0.02 \mu\text{g}/\text{m}^3$).
- Similar to the other New Jersey sites, concentrations of formaldehyde appear higher during the warmer months of the year, although the differences among the quarterly averages are not statistically significant for NBNJ. A review of the data shows that formaldehyde concentrations ranged from $0.613 \mu\text{g}/\text{m}^3$ to $5.82 \mu\text{g}/\text{m}^3$, with the three highest concentrations of formaldehyde (those greater than $5 \mu\text{g}/\text{m}^3$) measured in July, and all 14 formaldehyde concentrations greater than $3 \mu\text{g}/\text{m}^3$ measured during the second and third quarters of the year.
- Concentrations of acetaldehyde do not follow the same tendency as formaldehyde at NBNJ. Concentrations measured during the first quarter of the year were the lowest, based on the quarterly averages, while concentrations measured during the fourth quarter were similar to those measured during the second and third quarters. The maximum concentration of acetaldehyde was measured on November 21, 2013 ($2.96 \mu\text{g}/\text{m}^3$). Concentrations greater than $2 \mu\text{g}/\text{m}^3$ were measured in all calendar

quarters except the first quarter (with six measured during the second quarter, nine in the third, and five in the fourth).

- Concentrations of benzene appear highest during the first quarter of 2013 at NBNJ (although the differences among the quarterly averages are not statistically significant). Five of the six highest concentrations of benzene were measured at NBNJ in January and February.

Additional observations for the New Jersey sites from Table 20-5 include:

- Formaldehyde and acetaldehyde were the pollutants of interest with the highest annual average concentrations for each New Jersey site. Concentrations of these pollutants were higher at CSNJ and ELNJ than CHNJ and NBNJ. Concentrations of formaldehyde were higher during the warmer months of the year at each site, as indicated by the quarterly averages.
- Of the VOC pollutants of interest, benzene has the highest annual average concentration for three of the four sites, ranking second to carbon tetrachloride for CHNJ. Concentrations of benzene were also highest at CSNJ and ELNJ compared to CHNJ and NBNJ.
- Concentrations of hexachloro-1,3-butadiene were highest during the fourth quarter of 2013 at each New Jersey site, based on the quarterly averages shown in Table 20-5. This pollutant was detected in only 13 samples collected at ELNJ, with eight of them measured during the fourth quarter (and only one measured during the first quarter and two each in the second and third quarters of 2013). This is true across all of the New Jersey sites, with the number of measured detections of hexachloro-1,3-butadiene for the fourth quarter similar to or greater than the number of measured detections for the other three quarters combined. However, all measured detections of this pollutant are less than the MDL.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the New Jersey sites from those tables include the following:

- The New Jersey sites appear in Table 4-9 for VOCs a total of seven times (CSNJ, twice; CHNJ, once; ELNJ, twice; and NBNJ, twice).
- Three New Jersey sites appear in Table 4-9 for hexachloro-1,3-butadiene, with NBNJ, CSNJ, and CHNJ ranking third, fifth, and sixth, respectively, for this pollutant. ELNJ's annual average concentration is similar to the other sites, although it ranks 13th among NMP sites sampling VOCs. Most of the annual average concentrations of this pollutant across NMP sites are within $0.015 \mu\text{g}/\text{m}^3$ of each other.

- ELNJ has the ninth highest annual average concentration of ethylbenzene and the 10th highest annual average concentration of 1,3-butadiene among NMP sites sampling VOCs.
- CSNJ and NBNJ rank seventh and ninth, respectively, for their annual average concentrations of 1,2-dichloroethane.
- CSNJ and ELNJ both appear in Table 4-10 for both carbonyl compounds. CSNJ has the third highest annual average concentrations of both acetaldehyde and formaldehyde among NMP sites sampling carbonyl compounds. ELNJ has the fourth highest annual average concentration of formaldehyde and the fifth highest annual average concentration of acetaldehyde, the same rankings this site had for these pollutants in the 2012 NMP report.

20.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 20-4 for each of the New Jersey sites. Figures 20-12 through 20-21 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 20-12. Program vs. Site-Specific Average Acetaldehyde Concentrations

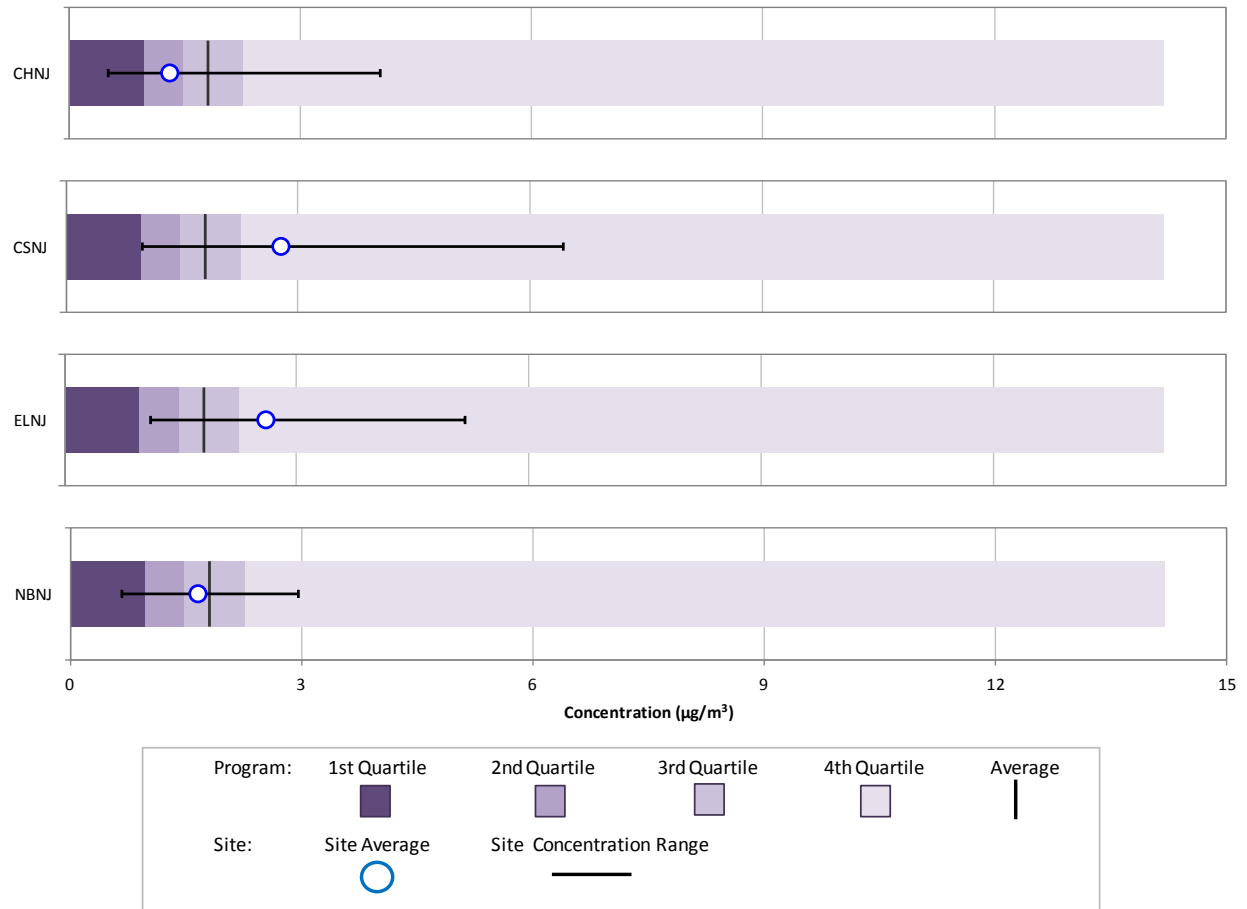


Figure 20-13. Program vs. Site-Specific Average Benzene Concentrations

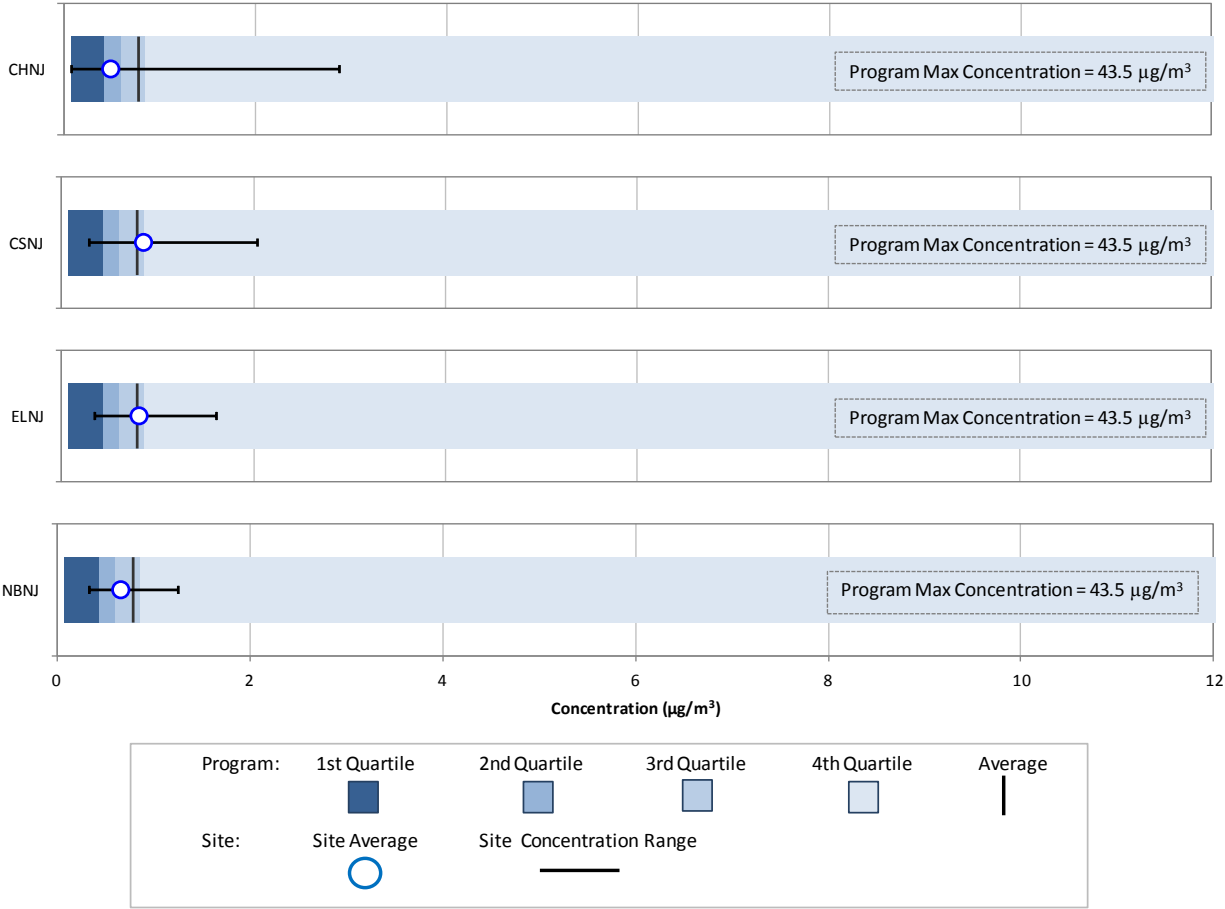


Figure 20-14. Program vs. Site-Specific Average Bromomethane Concentration

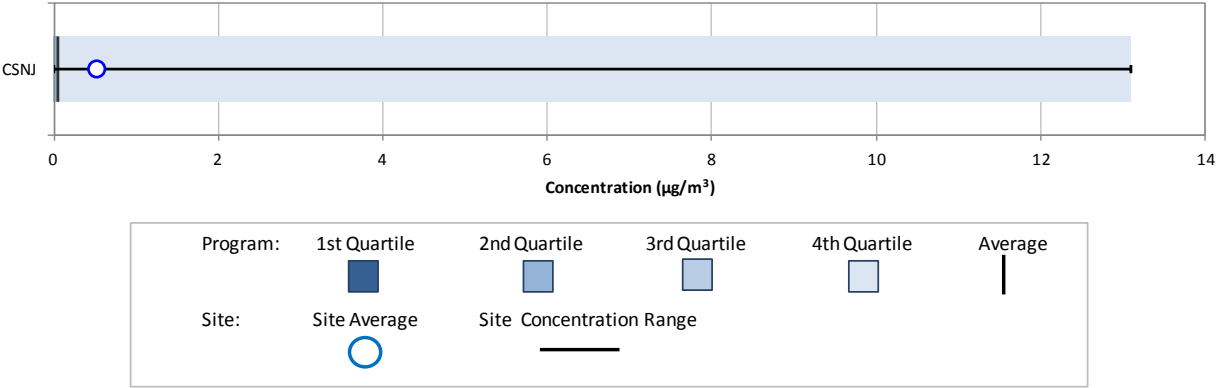


Figure 20-15. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

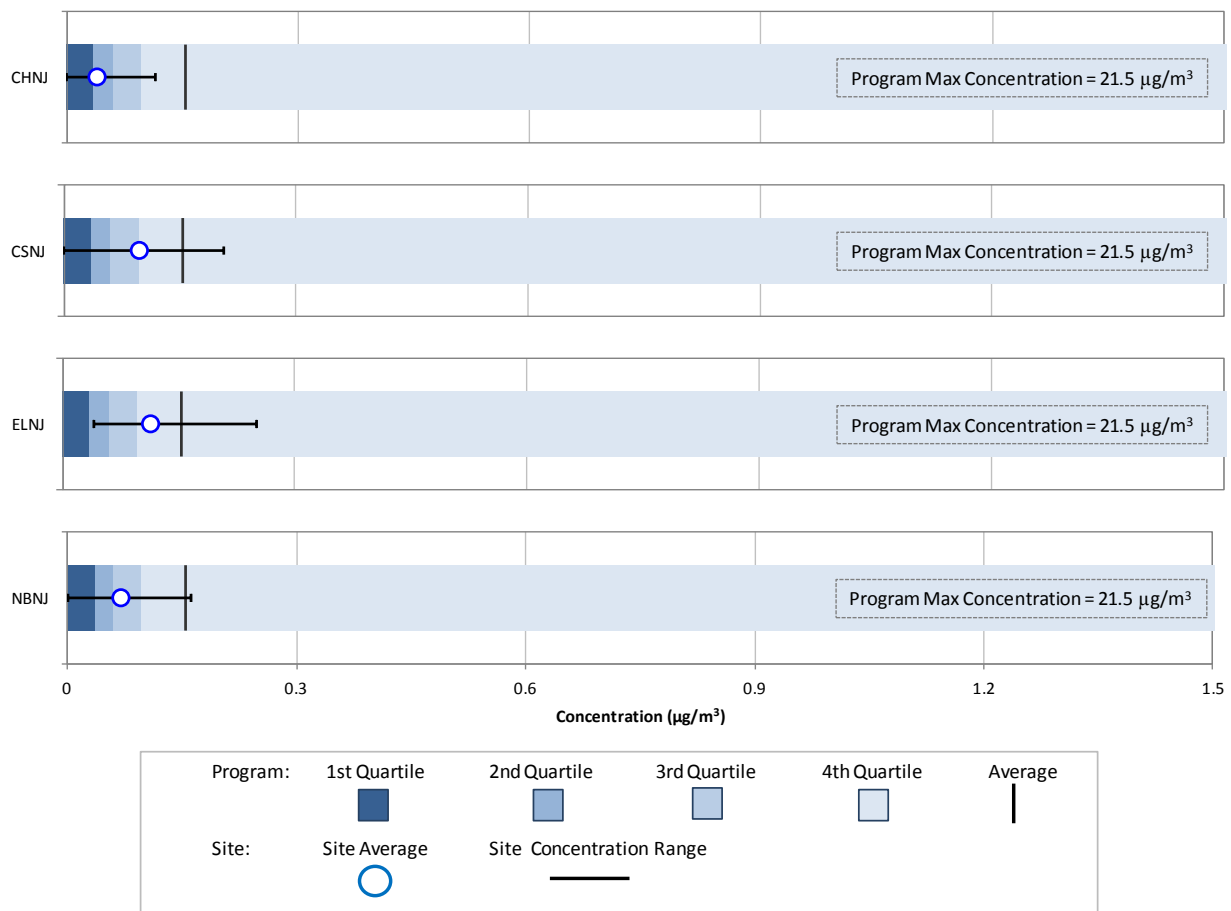


Figure 20-16. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations

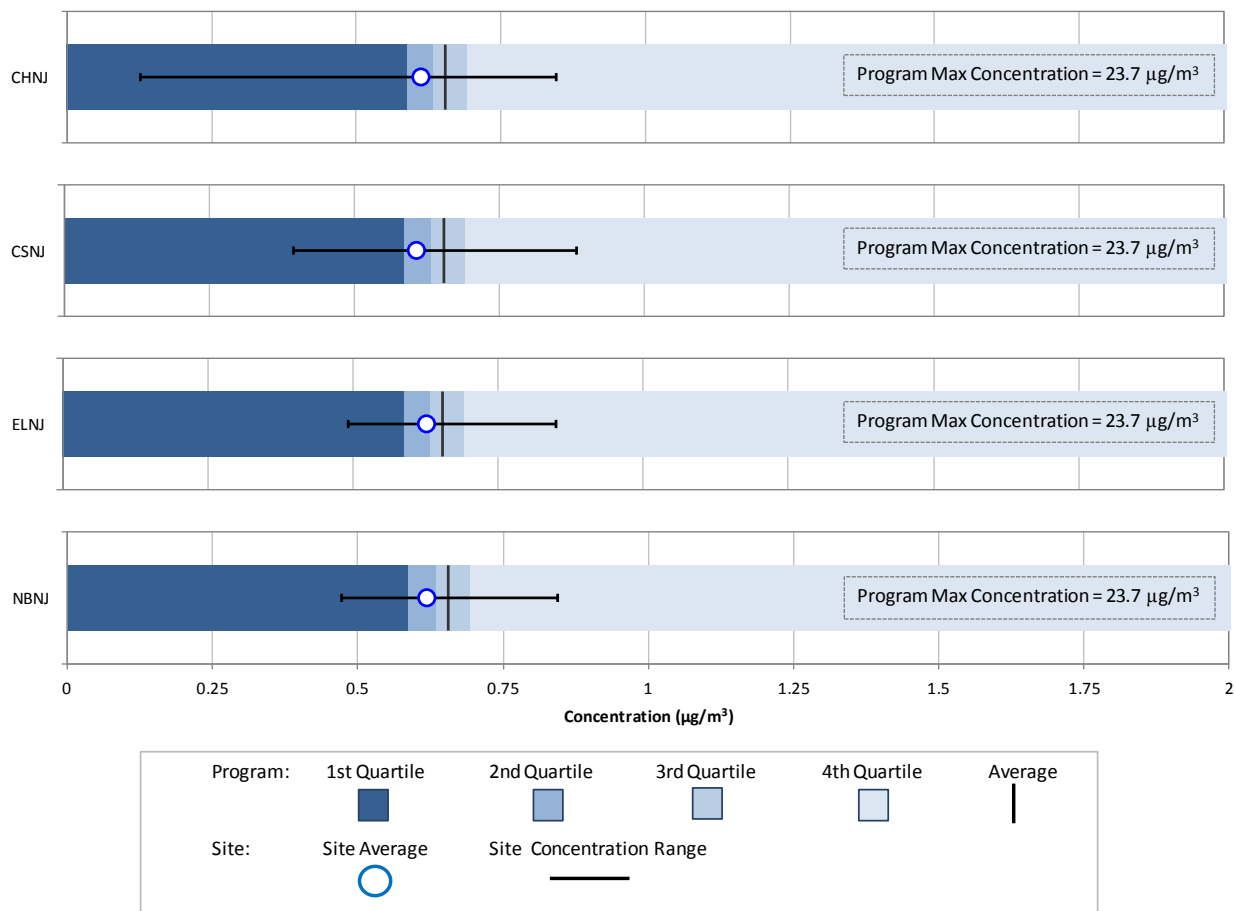


Figure 20-17. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations

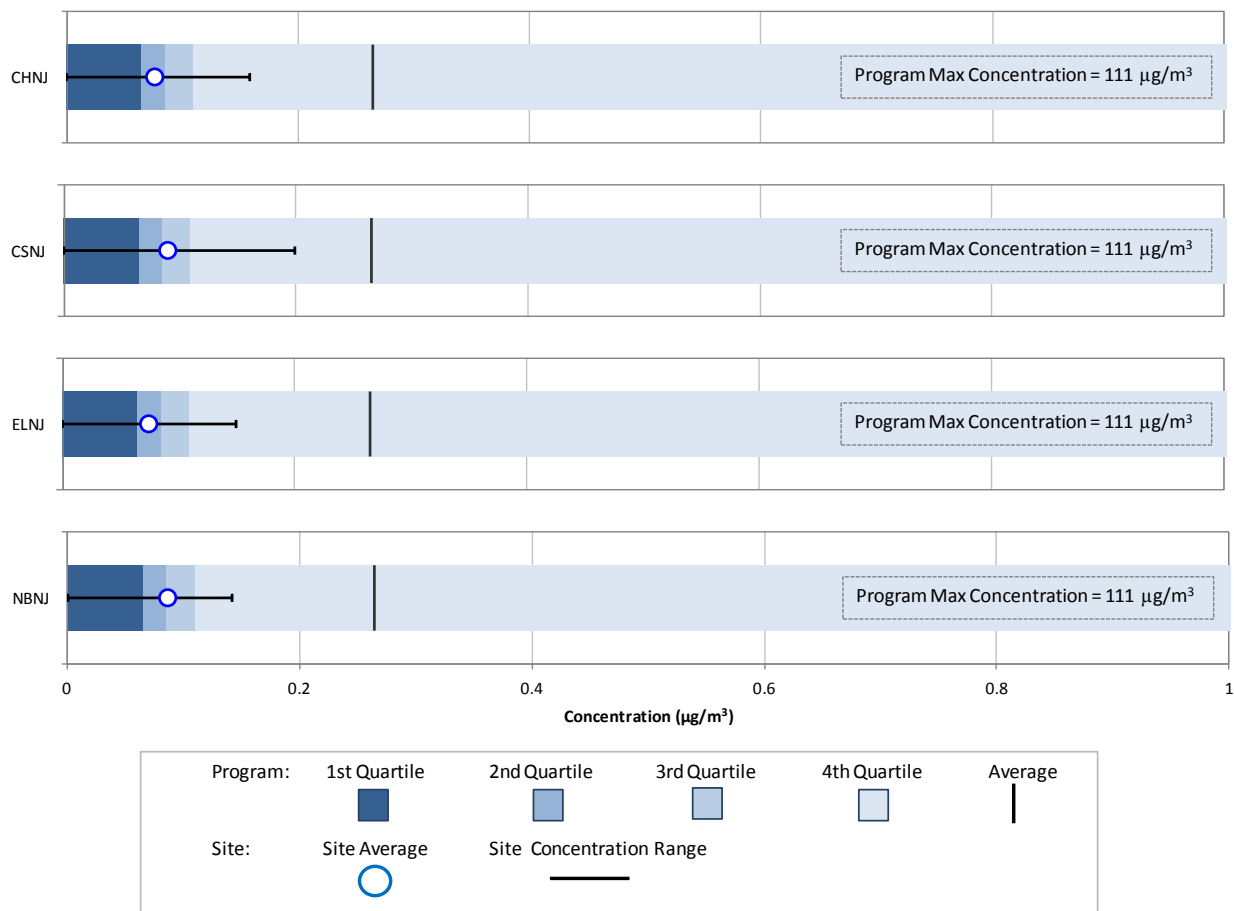


Figure 20-18. Program vs. Site-Specific Average Ethylbenzene Concentrations

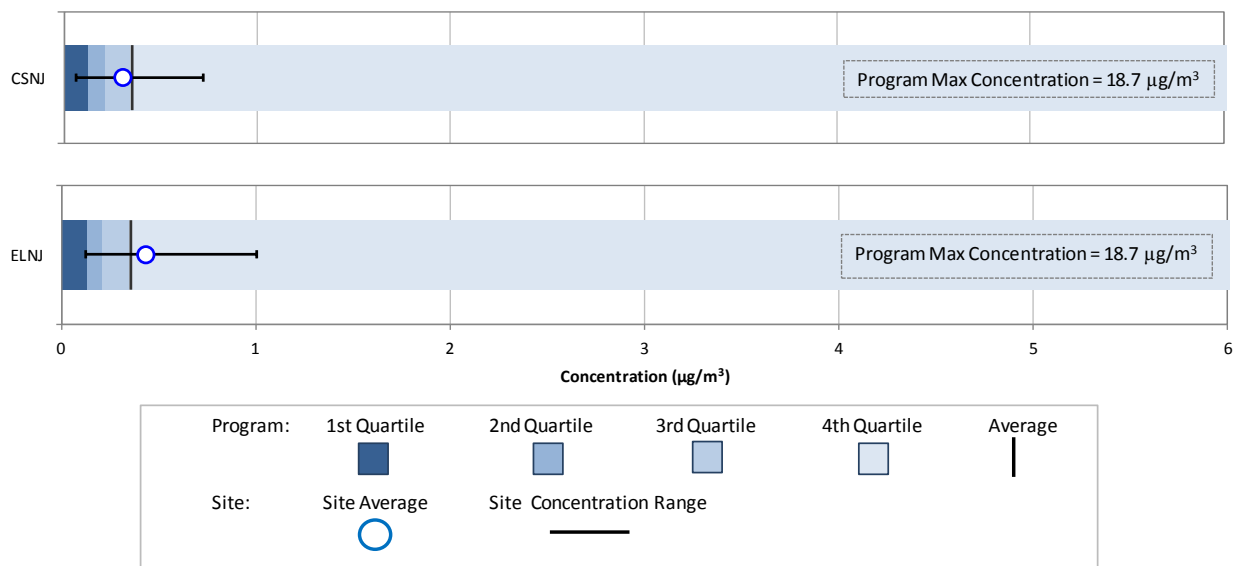


Figure 20-19. Program vs. Site-Specific Average Formaldehyde Concentrations

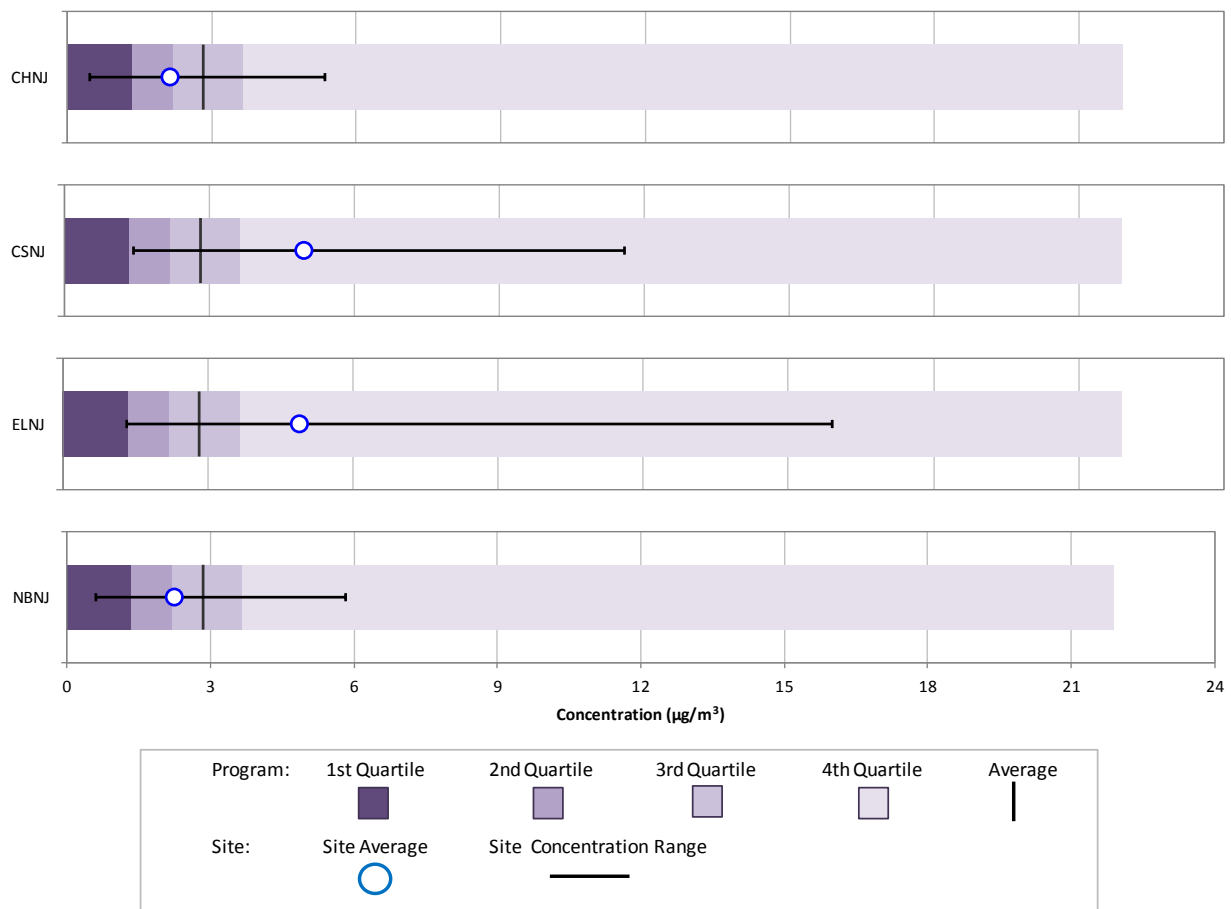


Figure 20-20. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentrations

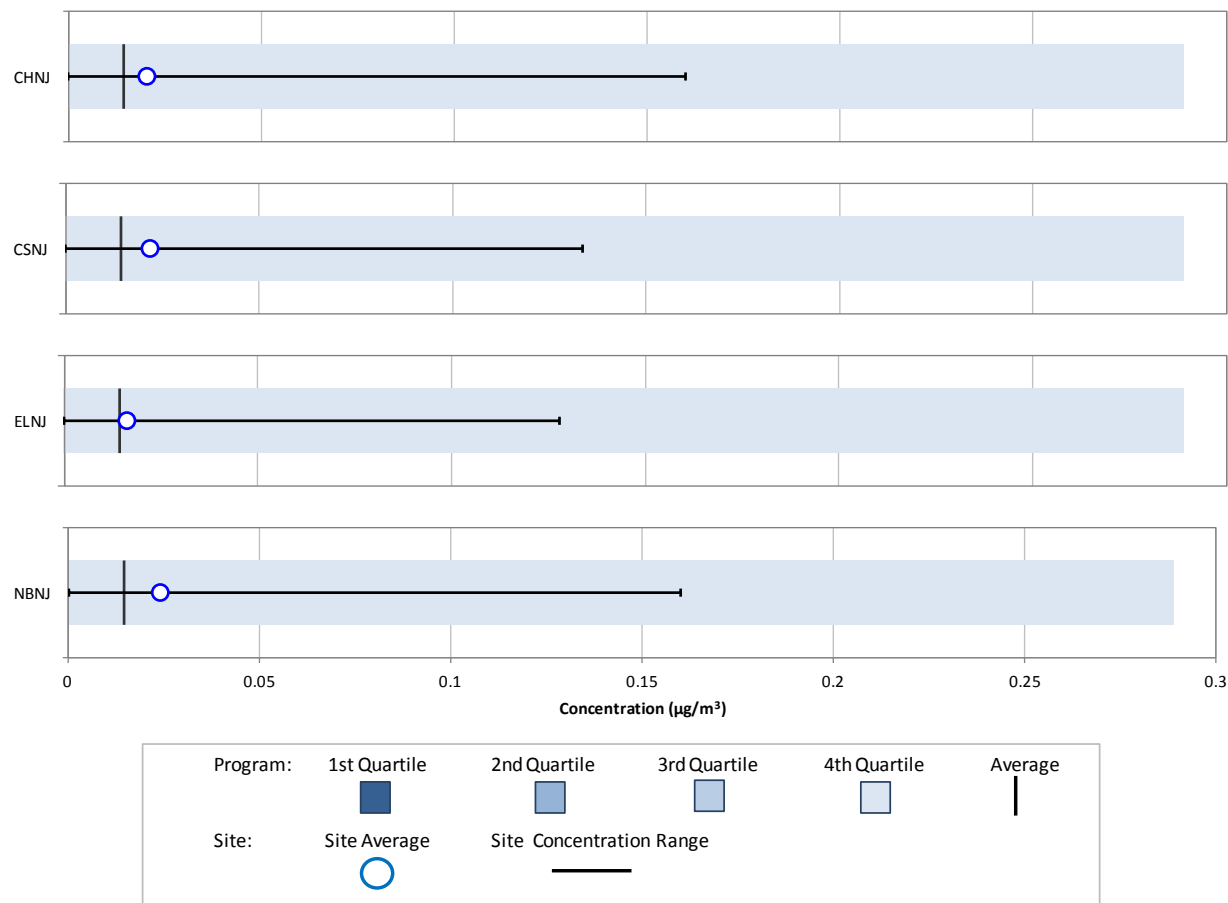
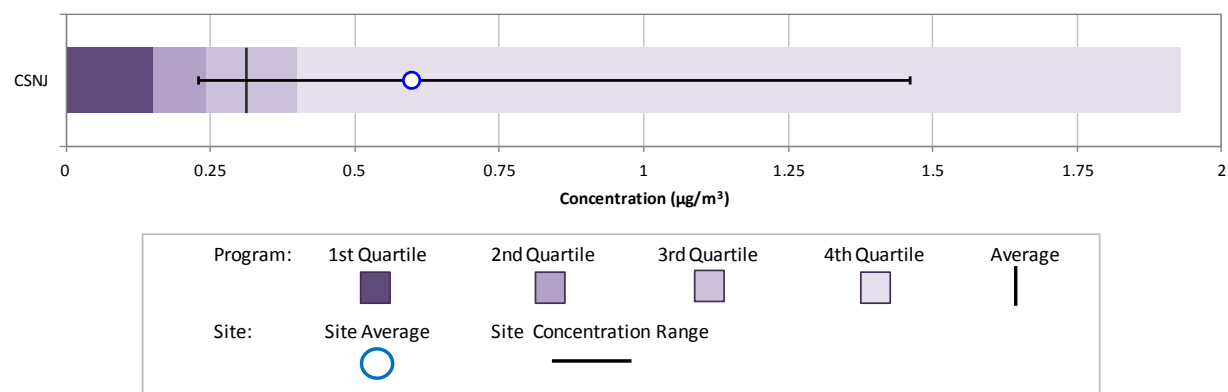


Figure 20-21. Program vs. Site-Specific Average Propionaldehyde Concentration



Observations from Figures 20-12 through 20-21 include the following:

- Figure 20-12 presents the box plots for acetaldehyde for all four New Jersey sites. The range of acetaldehyde concentrations measured is largest for CSNJ and smallest for NBNJ. The annual average concentration of acetaldehyde is highest for CSNJ and lowest for CHNJ. The annual average concentrations for CSNJ and ELNJ are greater than the program-level average concentration as well as the

program-level third quartile. The annual average concentration for NBNJ is less than the program-level average concentration but greater than the program-level median concentration while the annual average for CHNJ is less than both the program-level average and median concentrations. The minimum concentrations measured at CSNJ and ELNJ are greater than the program-level first quartile.

- Figure 20-13 presents the box plots for benzene. Note that the program-level maximum benzene concentration ($43.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots as the scale has been reduced to $12 \mu\text{g}/\text{m}^3$ to allow for the observation of data points at the lower end of the concentration range. The range of benzene concentrations measured at each New Jersey site is largest for CHNJ and smallest for NBNJ. The annual average benzene concentration for CSNJ is greater than the program-level average concentration; the annual average concentration for ELNJ is similar to the program-level average concentration; the annual average concentration for NBNJ is less than the program-level average concentration but just greater than the program-level median concentration; and CHNJ's annual average benzene concentration is less than both the program-level average and median concentrations. Even though the maximum benzene concentration among the New Jersey sites was measured at CHNJ, the minimum benzene concentration measured at an NMP site sampling benzene with Method TO-15 was also measured at CHNJ.
- Figure 20-14 presents the box plot for bromomethane for CSNJ, the only NMP site for which bromomethane is a pollutant of interest. Note that the first, second, and third quartiles for bromomethane are zero at the program-level and therefore not visible on the box plot due to the large number of non-detects. This box plot shows that the maximum concentration of bromomethane across the program was measured at CSNJ. All concentrations of bromomethane greater than $1 \mu\text{g}/\text{m}^3$ across the program were measured at CSNJ. CSNJ's annual average concentration of bromomethane ($0.52 \pm 0.50 \mu\text{g}/\text{m}^3$) is an order of magnitude greater than the program-level average concentration ($0.054 \mu\text{g}/\text{m}^3$).
- Figure 20-15 presents the box plots for 1,3-butadiene. Similar to benzene, the program-level maximum concentration ($21.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots as the scale has been reduced to $1.5 \mu\text{g}/\text{m}^3$ to allow for the observation of data points at the lower end of the concentration range. Among the New Jersey sites, the smallest range of 1,3-butadiene concentrations was measured at CHNJ while the largest range was measured at ELNJ, although a similar range was measured at CSNJ. ELNJ is the only site that did not measure any non-detects of this pollutant; in fact, the minimum concentration measured at ELNJ is greater than the program-level first quartile. The annual average 1,3-butadiene concentrations for all four sites are less than the program-level average concentration. However, the program-level average concentration is being driven by the higher measurements collected at a few sites. Among the New Jersey sites, the annual average concentration is lowest for CHNJ and highest for ELNJ, although only $0.07 \mu\text{g}/\text{m}^3$ separates them.

- Figure 20-16 presents the box plots for carbon tetrachloride. The scale of the box plots in Figure 20-16 has also been reduced to allow for the observation of data points at the lower end of the concentration range, as the program-level maximum carbon tetrachloride concentration ($23.7 \mu\text{g}/\text{m}^3$) is considerably greater than the majority of measurements. The range of carbon tetrachloride measurements is largest for CHNJ and lowest for ELNJ, although this is being driven by the minimum concentration measured at CHNJ. Excluding this data point would result in CHNJ's range of measurement resembling CSNJ's range of measurements. The annual average concentrations vary little among the New Jersey sites, although they are all less than the program-level average and median concentrations.
- Figure 20-17 presents the box plots for 1,2-dichloroethane. Similar to other VOCs, the program-level maximum concentration ($111 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots as the scale has been reduced to $1 \mu\text{g}/\text{m}^3$ to allow for the observation of data points at the lower end of the concentration range. The program-level average concentration is being driven by the higher measurements collected at a few monitoring sites. Figure 20-17 shows that the maximum 1,2-dichloroethane concentrations measured at the New Jersey sites are all less than $0.2 \mu\text{g}/\text{m}^3$, and thus, the entire range of measurements collected at each site is less than the average concentration across the program. The annual average concentrations for these sites are shown on either side of the program-level median concentration.
- Figure 20-18 presents the box plots for ethylbenzene for CSNJ and ELNJ, the only sites for which this is a pollutant of interest. The scale of the box plots in Figure 20-18 have also been reduced to allow for the observation of data points at the lower end of the concentration range. All of the ethylbenzene concentrations measured at these two sites are less than or equal to $1.0 \mu\text{g}/\text{m}^3$. The annual average concentration for ELNJ is just greater than the program-level average concentration and program-level third quartile. The range of measurements collected at CSNJ is smaller and its annual average concentration is less than the program-level average concentration.
- Figure 20-19 presents the box plots for formaldehyde for all four sites. The range of formaldehyde concentrations is smallest for CHNJ and largest for ELNJ. The annual average concentration of formaldehyde for ELNJ is similar to the annual average for CSNJ, both of which are greater than the program-level average concentration and third quartile. The annual average concentrations for CHNJ and NBNJ are similar to each other and the program-level median concentration. The minimum concentration measured at CSNJ is greater than the program-level first quartile.
- Figure 20-20 presents the box plots for hexchloro-1,3-butadiene for all four sites. Note that the first, second, and third quartiles for hexchloro-1,3-butadiene are zero at the program-level and therefore not visible on the box plots due to the large number of non-detects. The annual average hexchloro-1,3-butadiene concentrations for all four sites are greater than the program-level average

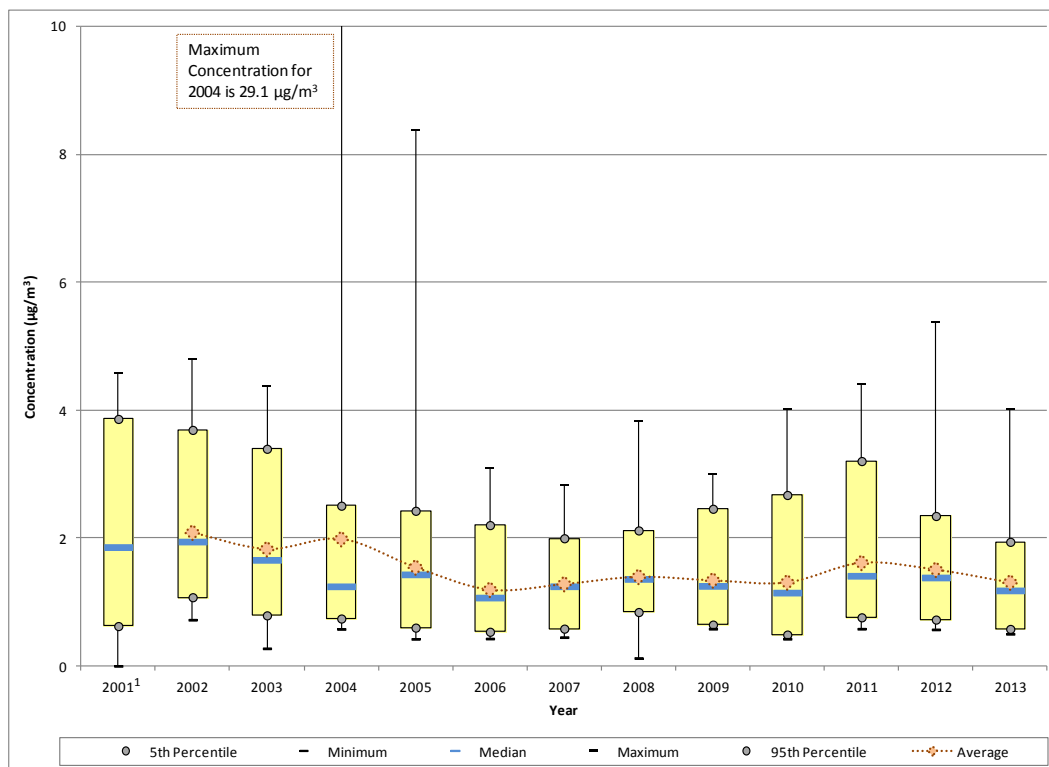
concentration, though by only a small margin. Roughly one-quarter of the measurements of these pollutants were measured detections, although none were greater than the MDL.

- Figure 20-21 presents the box plot for propionaldehyde for CSNJ, the only New Jersey site for which this is a pollutant of interest. The minimum concentration measured at CSNJ is greater than the program-level first quartile and just less than the program-level median concentration. The annual average concentration for CSNJ is nearly twice the program-level average concentration. CSNJ is one of only two NMP sites sampling carbonyl compounds with propionaldehyde as a pollutant of interest (BTUT is the other).

20.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. CHNJ, ELNJ, and NBNJ have sampled VOCs and carbonyl compounds under the NMP for many years. ELNJ has sampled under the NMP since 2000 and CHNJ and NBNJ since 2001. Thus, Figures 20-22 through 20-43 present the 1-year statistical metrics for each of the pollutants of interest first for CHNJ, then for ELNJ and NBNJ. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented. CSNJ began sampling under the NMP in 2013; thus, a trends analysis was not performed for this site.

Figure 20-22. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at CHNJ



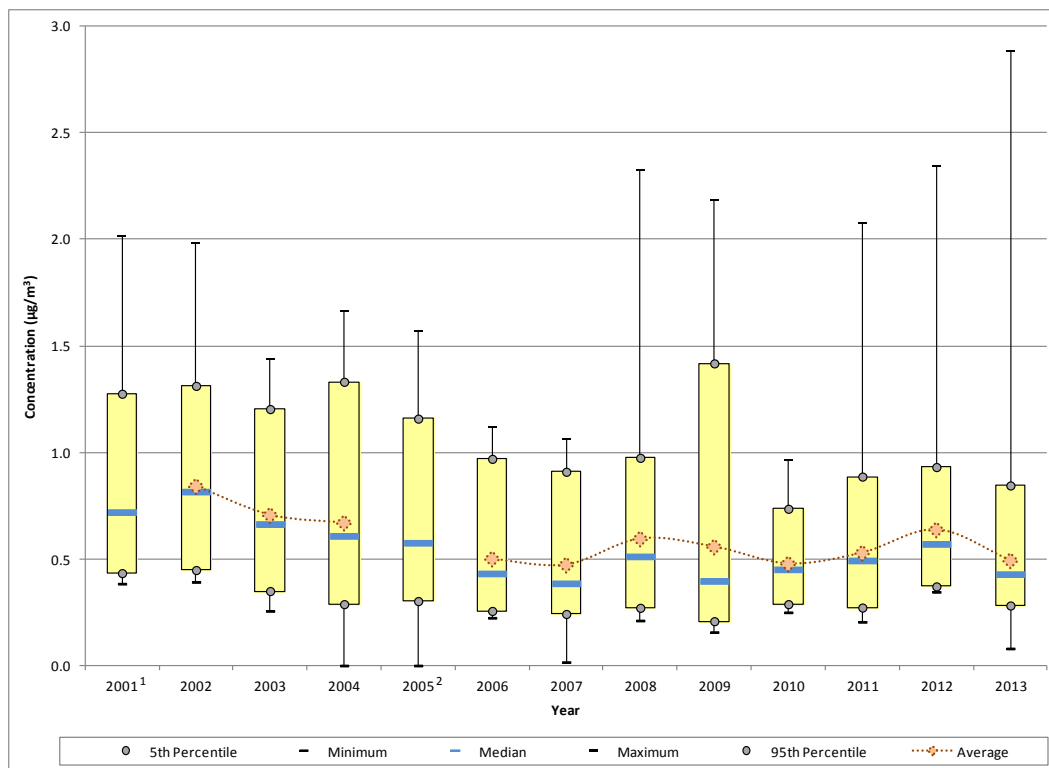
¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 20-22 for acetaldehyde measurements collected at CHNJ include the following:

- Sampling for carbonyl compounds under the NMP began at CHNJ in May 2001. Because a full year's worth of data is not available for 2001, a 1-year average concentration is not presented, although the range of measurements is provided.
- The two highest acetaldehyde concentrations were measured at CHNJ in 2004 ($29.1 \mu\text{g}/\text{m}^3$ and $11.5 \mu\text{g}/\text{m}^3$). All other concentrations measured in 2004 were less than $3 \mu\text{g}/\text{m}^3$. Only two additional acetaldehyde concentrations greater than $5 \mu\text{g}/\text{m}^3$ have been measured at CHNJ, one in 2005 ($8.38 \mu\text{g}/\text{m}^3$) and one in 2012 ($5.38 \mu\text{g}/\text{m}^3$).
- An overall decreasing trend in the 1-year average and median concentrations is shown through 2006, with the exception of 2004, when the maximum concentrations were measured. Between 2006 and 2010, the 1-year average and median concentrations changed little, with the 1-year average concentrations varying by less than $0.25 \mu\text{g}/\text{m}^3$ over these years.
- All of the statistical metrics exhibit an increase from 2010 to 2011. Although the maximum concentration increased again for 2012, the 95th percentile decreased nearly $1 \mu\text{g}/\text{m}^3$, indicating that fewer concentrations at the upper end of the range were measured in 2012. The second highest concentration measured in 2012 is half

the magnitude of the maximum concentration for 2012. Additional decreases for all of the statistical parameters are shown for 2013.

Figure 20-23. Yearly Statistical Metrics for Benzene Concentrations Measured at CHNJ



¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

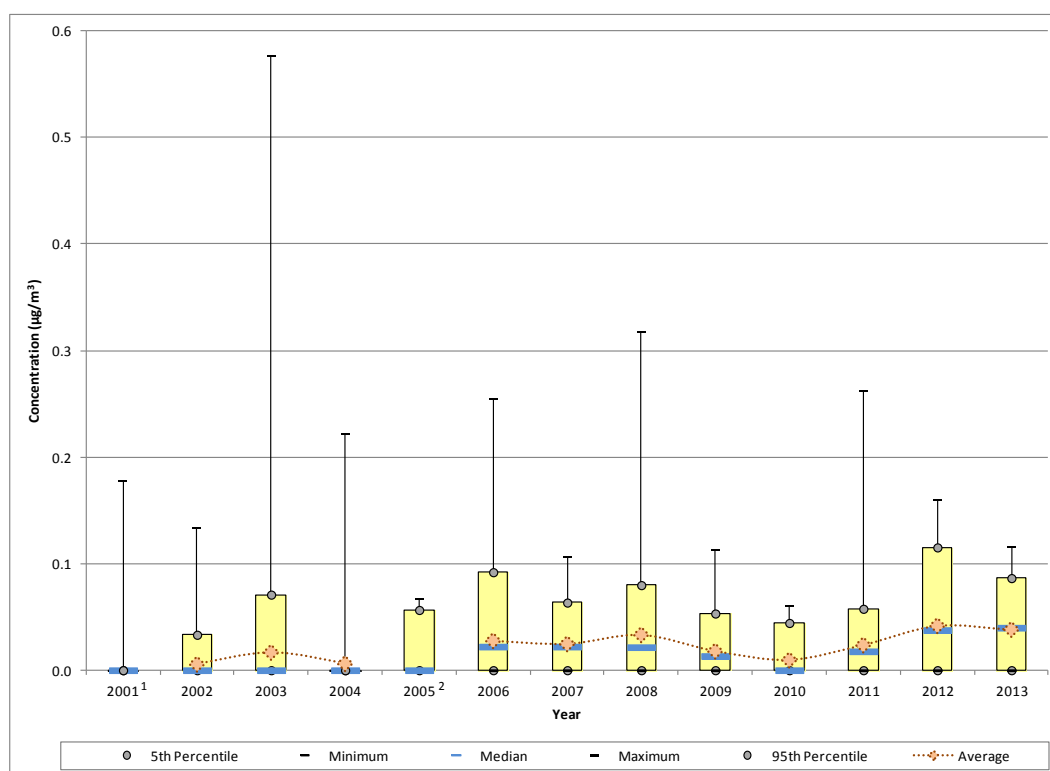
² A 1-year average is not presented due to low completeness in 2005.

Observations from Figure 20-23 for benzene measurements collected at CHNJ include the following:

- Similar to carbonyl compounds, sampling for VOCs under the NMP began at CHNJ in May 2001. Because a full year's worth of data is not available, a 1-year average concentration is not presented, although the range of measurements is provided. In addition, a 1-year average concentration for 2005 is not provided due to low completeness.
- The maximum benzene concentration measured at CHNJ was measured on September 13, 2013 (2.88 $\mu\text{g}/\text{m}^3$). Only nine benzene concentrations greater than 2 $\mu\text{g}/\text{m}^3$ have been measured at CHNJ since the onset of sampling (one was measured in 2001, two in 2008, three in 2009, and one each in 2011, 2012, and 2013).
- The 1-year average and median concentrations exhibit a decreasing trend through 2007, although a 1-year average concentration is not provided for 2001 or 2005.

- Even though an increase in the 1-year average concentration is shown from 2007 to 2008, this increase is being driven less by the two measurements greater than $2 \mu\text{g}/\text{m}^3$ and more by the measurements in the mid- to upper-end of the concentration range. This is evident from the increase shown in the median concentration. The number of concentrations between $0.5 \mu\text{g}/\text{m}^3$ and $1 \mu\text{g}/\text{m}^3$ nearly doubled from 2007 to 2008 (from 15 to 28).
- The difference between the 5th and 95th percentiles, or the range within which the majority of concentrations fall, is at a maximum for 2009, indicating an increase in variability of the concentrations measured. Conversely, the difference between the 5th and 95th percentiles is at a minimum for the following year.
- An increase in the 1-year average, median, 95th percentile, and maximum concentrations is shown from 2010 to 2011 and again for 2012. Although the range of concentrations measured is at a maximum for 2013, all of the statistical metrics exhibit decreases for 2013.
- Although an undulating pattern is shown in the 1-year average concentrations of benzene between 2006 and 2013, the averages have varied by less than $0.2 \mu\text{g}/\text{m}^3$, ranging from $0.47 \mu\text{g}/\text{m}^3$ (2007) to $0.64 \mu\text{g}/\text{m}^3$ (2012).

Figure 20-24. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at CHNJ



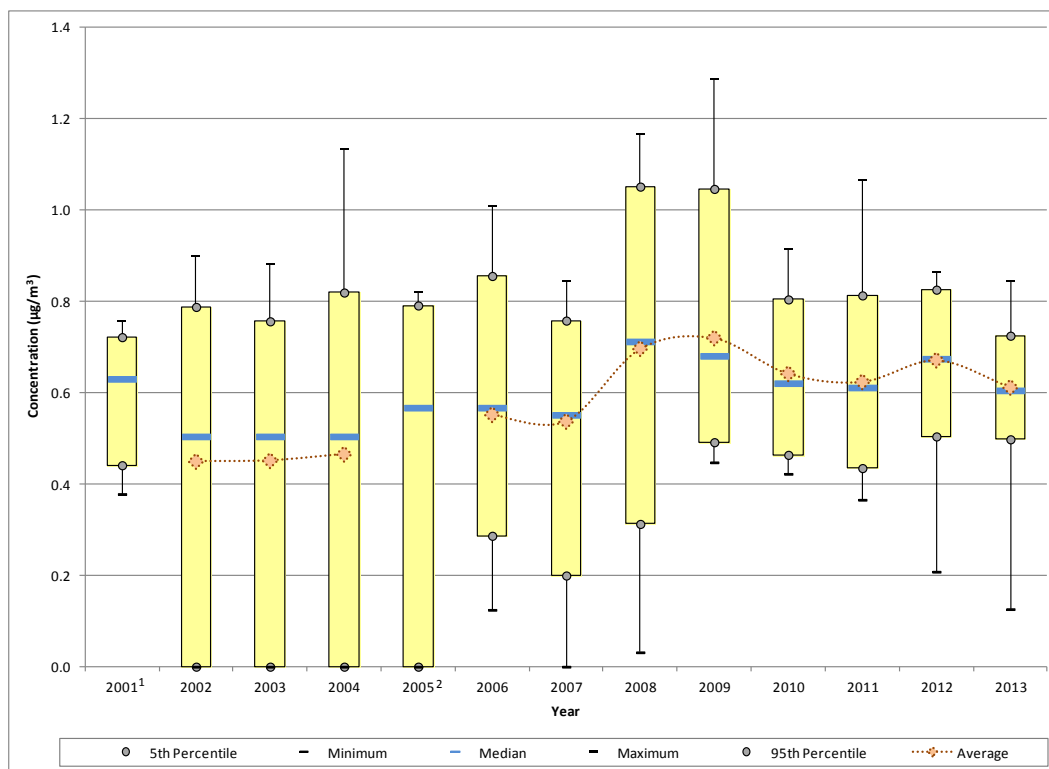
¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

² A 1-year average is not presented due to low completeness in 2005.

Observations from Figure 20-24 for 1,3-butadiene measurements collected at CHNJ include the following:

- The maximum 1,3-butadiene concentration was measured in 2003 ($0.58 \mu\text{g}/\text{m}^3$) and is the only concentration greater than $0.5 \mu\text{g}/\text{m}^3$ measured at CHNJ. Only five 1,3-butadiene concentrations measured at CHNJ are greater than $0.2 \mu\text{g}/\text{m}^3$.
- For 2001 and 2004, the minimum, 5th percentile, median, and 95th percentile are all zero. This is because the percentage of non-detects was greater than 95 percent for these years. More than 50 percent of the measurements were non-detects between 2001 and 2005 (as well as 2010), as indicated by the median concentration. The percentage of non-detects decreased steadily between 2004 (96 percent) and 2008 (17 percent), when the percentage of non-detects reached a minimum. After 2008, the percentage of non-detects reported varied considerably, from as low as 18 percent (2012) and as high as 70 percent (2010).
- The 1-year average and median concentrations have a decreasing trend from 2008 through 2010 and then an increasing trend through 2012. These changes correspond with the changes in the number of non-detects/measured detections discussed above.
- Despite the increase in the number of non-detects, and thus zero substitutions, from 2012 to 2013 (from 11 to 17) and the smaller range of concentrations measured, the changes in the 1-year average and median concentrations are minimal.

Figure 20-25. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at CHNJ



¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

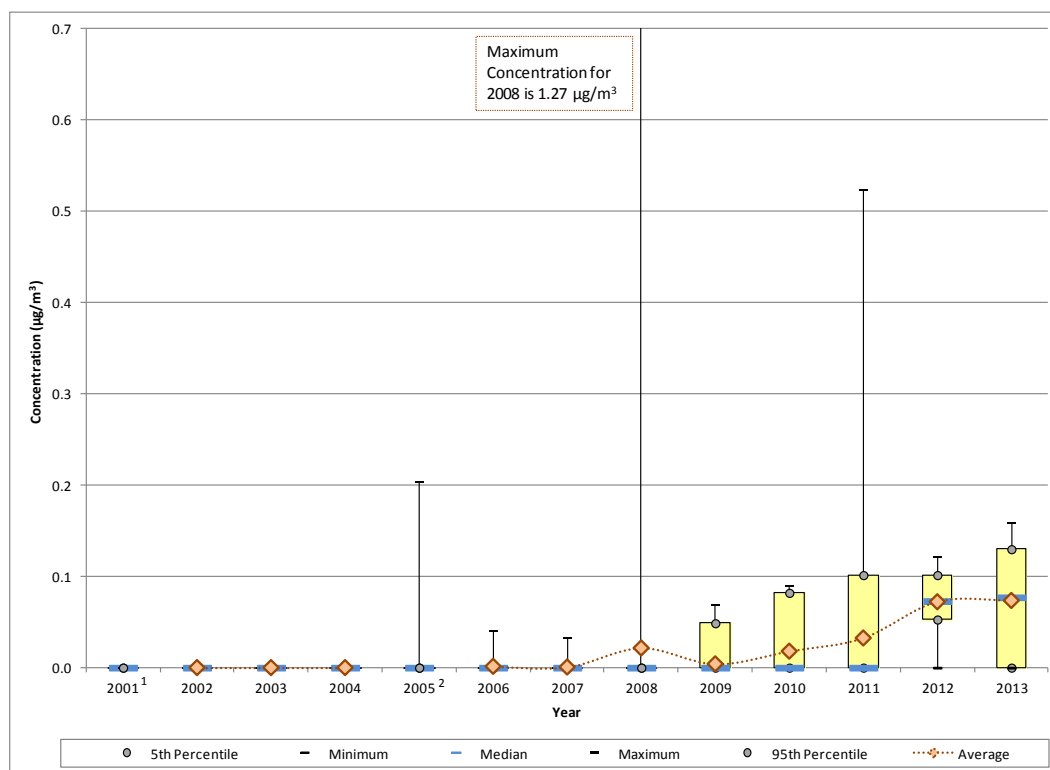
² A 1-year average is not presented due to low completeness in 2005.

Observations from Figure 20-25 for carbon tetrachloride measurements collected at CHNJ include the following:

- The range of carbon tetrachloride concentrations measured appear to increase significantly from 2001 to 2002, with fairly similar ranges measured between 2003 and 2005. This apparent increase is predominantly due to a few non-detects that were measured between 2002 and 2005. After 2005, only one non-detect was reported (2007).
- All of the statistical parameters exhibit an increase from 2007 to 2008. The 95th percentile for 2007 is just greater than the 1-year average and median concentrations calculated for 2008. There were 14 measurements in 2008 that were greater than the maximum concentration measured in 2007. The number of measurements greater than $0.6 \mu\text{g}/\text{m}^3$ more than doubled from 2007 to 2008.
- The minimum concentration measured in 2009 increased by an order of magnitude from 2008 and the maximum concentration increased as well. Yet the 1-year average increased only slightly from 2008 to 2009 and the median concentration decreased slightly.

- The minimum carbon tetrachloride concentration decreased every year after 2009, as did the maximum concentration, with the exception of 2011. Between 2009 and 2013, the range within which most of the concentrations fell, as indicated by the difference between the 5th and 95th percentiles, decreased each year (except for 2011), and is at a minimum for 2013 for all the years of sampling.
- Between 2008 and 2013, the 1-year average concentrations varied by less than $0.11 \mu\text{g}/\text{m}^3$.

Figure 20-26. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at CHNJ



¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

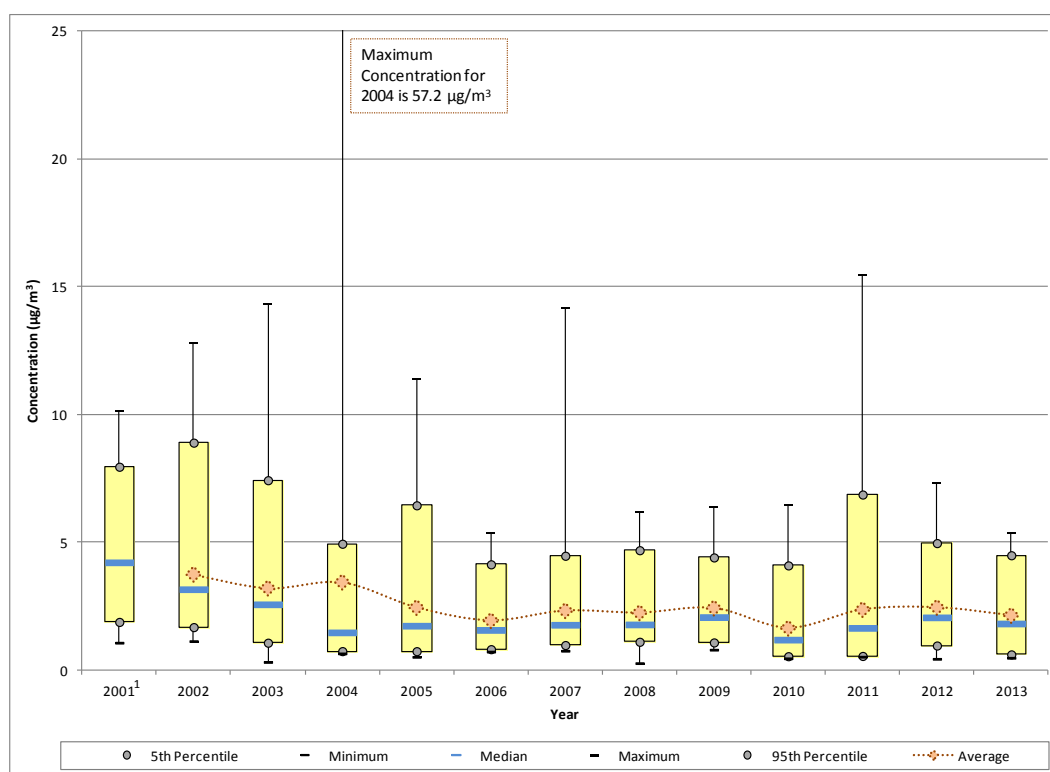
² A 1-year average is not presented due to low completeness in 2005.

Observations from Figure 20-26 for 1,2-dichloroethane measurements collected at CHNJ include the following:

- There were no measured detections of 1,2-dichloroethane between 2001 and 2004. There were one or two measured detections each year between 2005 and 2008. After 2008, the number of measured detections increased significantly, from 7 percent in 2009, to 25 percent for 2010, 30 percent in 2011, and 95 percent for 2012. This explains the significant increase in the 1-year average concentrations shown for the later years of sampling. The number of measured detections decreased slightly for 2013 but still account for the majority of measurements.

- 2012 is the first year that the median concentration and 5th percentile are greater than zero. Aside from the three non-detects, the range of measurements collected in 2012 is relatively small, ranging from 0.0527 $\mu\text{g}/\text{m}^3$ to 0.121 $\mu\text{g}/\text{m}^3$. The 1-year average and median concentrations calculated for 2012 are less than 0.001 $\mu\text{g}/\text{m}^3$ apart, indicating little variability associated with the measurements collected in 2012.
- The 5th percentile returned to zero for 2013, as six additional non-detects were measured in 2013. However, the 1-year average and median concentrations did not change. The effects of the additional non-detects are balanced by the additional concentrations measured at the upper end of the concentration range. The number of 1,2-dichloroethane concentrations greater than 0.1 $\mu\text{g}/\text{m}^3$ doubled from 2012 to 2013, increasing from four to nine.

Figure 20-27. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at CHNJ



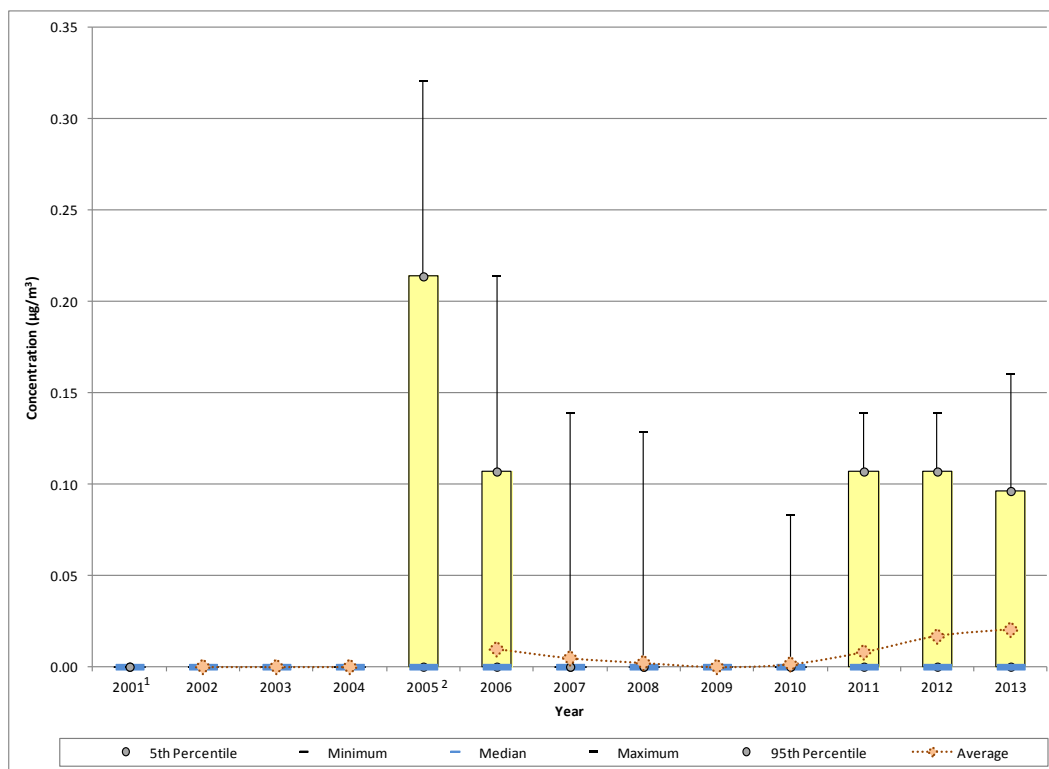
¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 20-27 for formaldehyde measurements collected at CHNJ include the following:

- The two highest formaldehyde concentrations were measured on the same days in 2004 as the two highest concentrations of acetaldehyde. The maximum concentration of formaldehyde (57.2 $\mu\text{g}/\text{m}^3$) is nearly twice the second highest concentration and almost four times the maximum concentrations shown for other years.

- A decreasing trend in the 1-year average and median formaldehyde concentrations is shown through 2006, after which the 1-year average and median concentrations changed little through 2009. Less than $0.5 \mu\text{g}/\text{m}^3$ separates the 1-year average concentrations calculated for the period between 2006 and 2009.
- The 1-year and median concentrations decreased significantly for 2010, when both statistical parameters are at a minimum. This is due primarily to the measurements at the lower end of the concentration range. The number of concentrations less than $1 \mu\text{g}/\text{m}^3$ increased from two in 2009 to 21 in 2010.
- Similar to acetaldehyde, all of the statistical metrics calculated for formaldehyde exhibit an increase from 2010 to 2011, including the 95th percentile, which is greater than the maximum concentration measured in 2010. Four formaldehyde concentrations measured in 2011 are greater than the maximum concentration measured in 2010. Although the range of measurements decreased for 2012, little change is shown in the 1-year average concentration and the median continued to increase. This is due to a lower number of concentrations at the lower end of the concentration range. The number of measurements less than $1 \mu\text{g}/\text{m}^3$ fell from 19 in 2011 to four in 2012.
- With the exception of the minimum concentration, all of the statistical parameters exhibit decreases for 2013. The maximum formaldehyde concentration measured at CHNJ in 2013 is the lowest maximum for any given year.

Figure 20-28. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at CHNJ



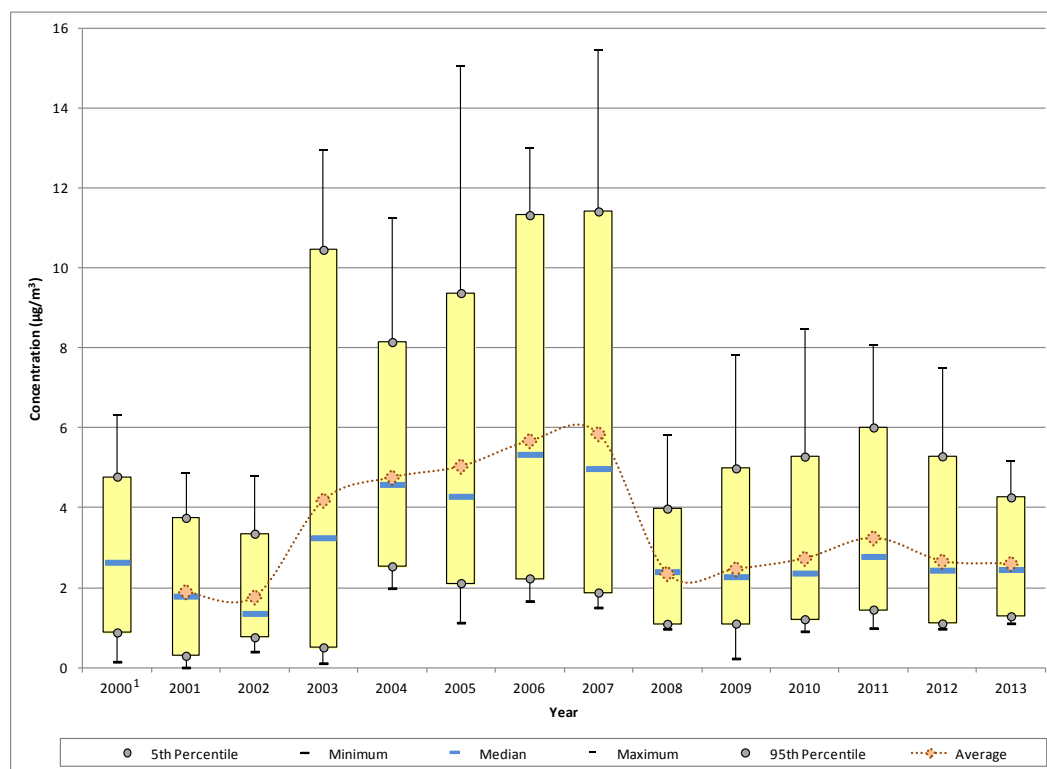
¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

² A 1-year average is not presented due to low completeness in 2005.

Observations from Figure 20-28 for hexachloro-1,3-butadiene measurements collected at CHNJ include the following:

- There were no measured detections of hexachloro-1,3-butadiene measured during the first 4 years of sampling.
- The number of measured detections increased to seven for 2005, representing 14 percent of measurements, then decreased each year through 2009, when again no measured detections were measured. The number of measured detections began increasing again after 2009, with one measured in 2010, four in 2011, 12 in 2012, and 14 in 2013, which is the maximum number of measured detections since sampling began.

Figure 20-29. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at ELNJ



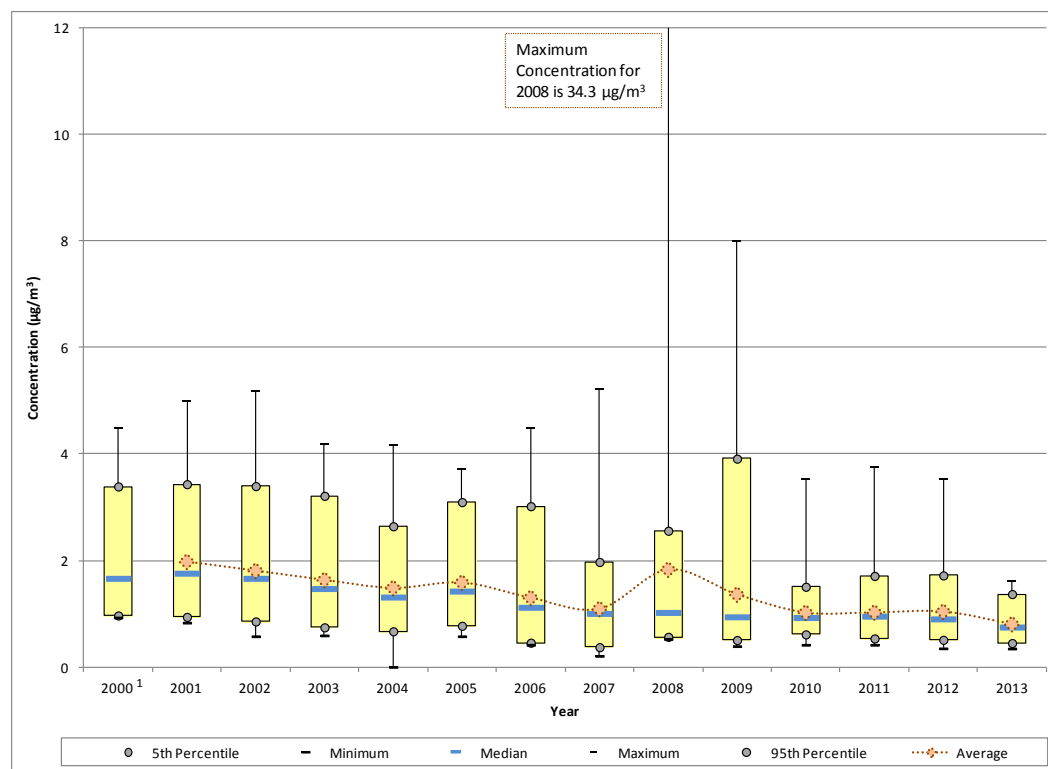
¹ A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 20-29 for acetaldehyde measurements collected at ELNJ include the following:

- ELNJ is the longest running NMP site. Carbonyl compound sampling under the NMP began at ELNJ in January 2000. However, sporadic sampling at the beginning of 2000 combined with a 1-in-12 day sampling schedule led to completeness less than 85 percent. Thus, a 1-year average concentration is not presented for 2000, although the range of measurements is provided.
- The maximum acetaldehyde concentration was measured at ELNJ in 2007, although a concentration of similar magnitude was also measured in 2005. In total, 22 concentrations greater than 10 $\mu\text{g}/\text{m}^3$ have been measured at ELNJ, all of which were measured prior to 2008.
- The range of concentrations measured between 2003 and 2007 is considerably higher than those collected during the first 3 years of sampling. The 1-year average concentration increased significantly from 2002 to 2003. This increasing trend continued through 2007, although the rate of change slowed over the years. A significant decrease in the measurements is shown from 2007 to 2008, where the 1-year average decreased by more than half. The range of measurements collected in 2008 is more similar to the range shown before 2003.

- Although an increasing trend is also shown between 2008 and 2011, the 1-year average concentrations are roughly half the magnitude of those shown before 2008.
- All of the statistical parameters exhibit decreases from 2011 to 2012 with additional decreases shown for some of the parameters for 2013. The range of measurements collected in 2013 is the smallest since the onset of sampling at ELNJ. The maximum concentration measured in 2013 is at its lowest since 2002.

Figure 20-30. Yearly Statistical Metrics for Benzene Concentrations Measured at ELNJ



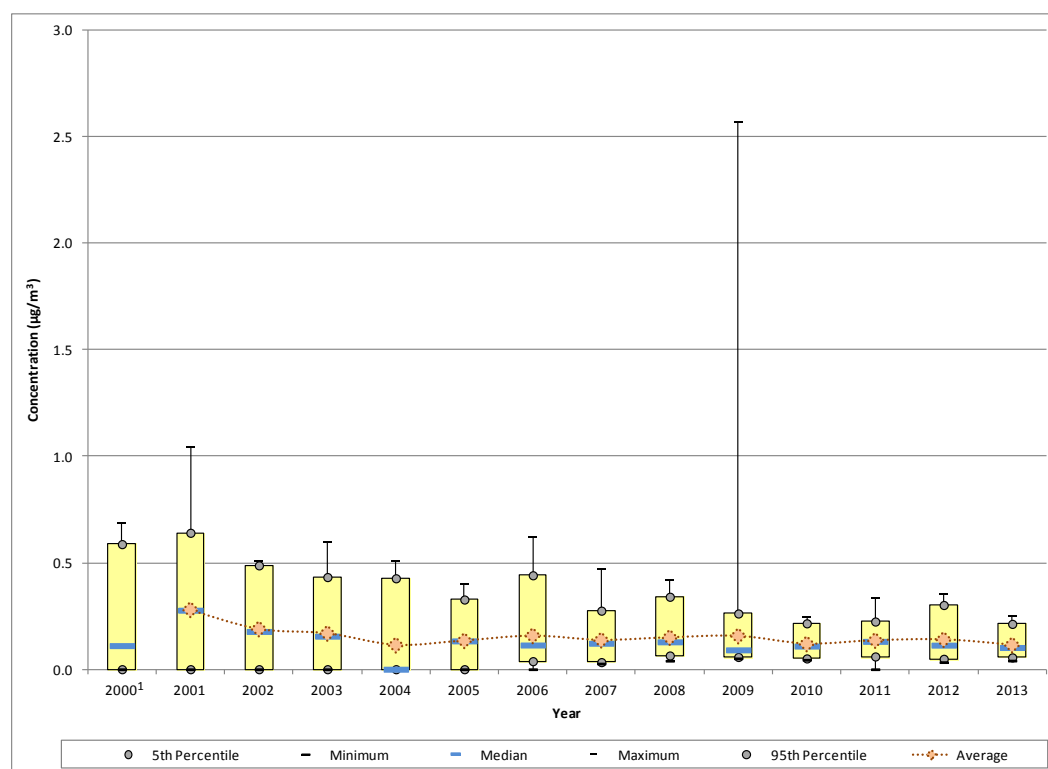
¹ A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 20-30 for benzene measurements collected at ELNJ include the following:

- VOC sampling under the NMP also began at ELNJ in January 2000. However, a 1-year average concentration is not presented for 2000 due to low completeness, although the range of measurements is provided.
- The maximum benzene concentration ($34.3 \mu\text{g}/\text{m}^3$) was measured in 2008 and is more than four times higher than the next highest concentration (measured in 2009). The third highest concentration was also measured in 2009. In all, only five benzene concentrations greater than $5 \mu\text{g}/\text{m}^3$ have been measured at ELNJ.
- A fairly steady decreasing trend in the 1-year average and median concentrations is shown through 2007.

- All of the statistical parameters exhibit at least a slight increase for 2008. If the maximum concentration for 2008 was removed from the data set, the 1-year average concentration would exhibit a negligible increase for 2008. Thus, it is this single concentration that is primarily driving the change in the 1-year average concentration. The median concentration is influenced less by outliers, as this statistical parameter represents the midpoint of a data set. The median increased by less than $0.02 \mu\text{g}/\text{m}^3$ between 2007 and 2008 further indicating that this outlier is the primary driver pulling the 1-year average concentration upward. However, the minimum concentration doubled from 2007 to 2008 and the 5th percentile increased as well, indicating that the outlier may not be the only factor.
- Even though two of the three highest concentrations were measured at ELNJ in 2009, the 1-year average concentration decreased from 2008 to 2009, likely a result of the magnitude of the outlier affecting the 2008 calculations.
- Figure 20-30 shows that benzene concentrations measured in 2010, 2011, and 2012 were fairly consistent. The difference in the 1-year average concentrations for these years is less than $0.02 \mu\text{g}/\text{m}^3$.
- Additional decreases are shown for 2013, as no benzene concentrations greater than $2 \mu\text{g}/\text{m}^3$ were measured in 2013, the only year for which this is true. The 1-year average benzene concentration is at a minimum for 2013, and is the only 1-year average concentration less than $1 \mu\text{g}/\text{m}^3$.

Figure 20-31. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at ELNJ

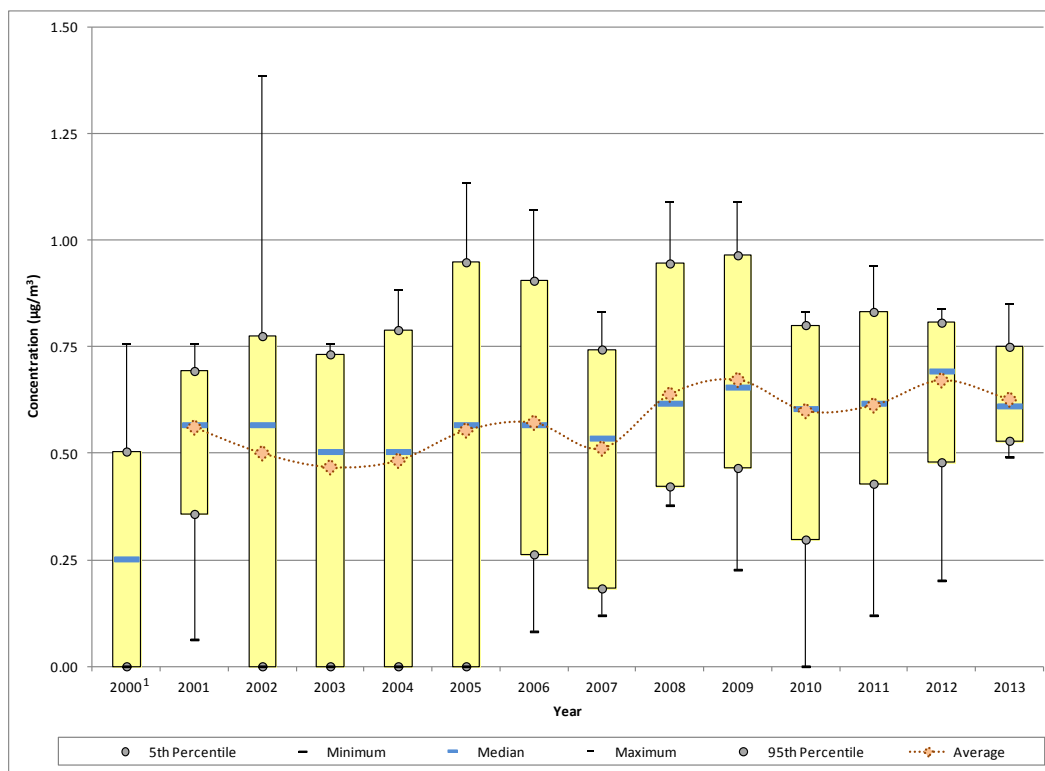


¹ A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 20-31 for 1,3-butadiene measurements collected at ELNJ include the following:

- The maximum concentration of 1,3-butadiene was measured in 2009 and is nearly two and a half times the next highest concentration (measured in 2001). These are the only concentrations of 1,3-butadiene measured at ELNJ that are greater than $1 \mu\text{g}/\text{m}^3$ and only 15 concentrations measured at ELNJ are greater than $0.5 \mu\text{g}/\text{m}^3$.
- The minimum and 5th percentile are zero for the first 6 years of sampling, indicating that at least 5 percent of the measurements were non-detects. For 2004, the median concentration is also zero, indicating that at least half of the measurements were non-detects. Between 2000 and 2006, the percentage of non-detects ranged from 5 percent (2006) to 57 percent (2004). After 2006, only two non-detects have been measured (both in 2011).
- There is a decreasing trend in the 1-year average concentration through 2004, after which the 1-year average concentration remains fairly static. Even with the higher concentration measured in 2009, the 1-year average concentration for 2009 is similar to the 1-year average concentration for 2008. Between 2005 and 2012, the 1-year average concentration has ranged from $0.12 \mu\text{g}/\text{m}^3$ (2010) to $0.16 \mu\text{g}/\text{m}^3$ (2006 and 2009).
- Concentrations of 1,3-butadiene measured at ELNJ have become less variable in recent years, with concentrations measured in 2010 and 2013 exhibiting the least variability. These two years have the smallest range of concentrations measured and the smallest differences between the 5th and 95th percentiles, the range within which the majority of concentrations fall.

Figure 20-32. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at ELNJ

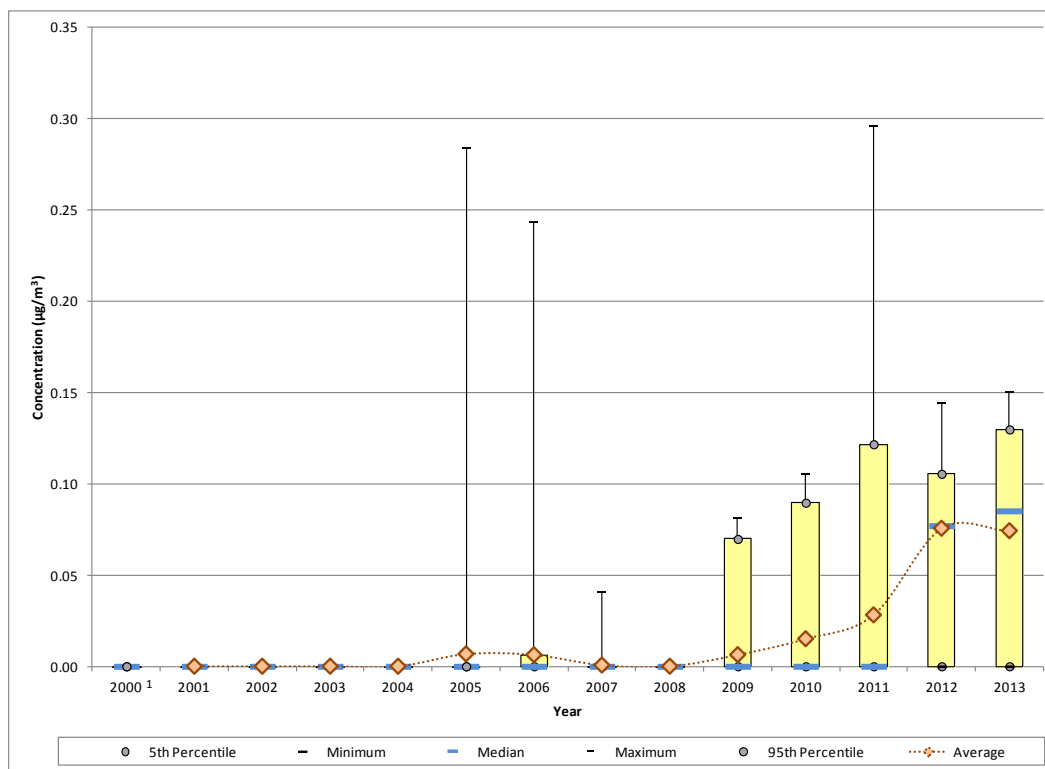


¹ A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 20-32 for carbon tetrachloride measurements collected at ELNJ include the following:

- The trends graph for carbon tetrachloride concentrations measured at ELNJ resembles the trends graph for CHNJ.
- The minimum and 5th percentile are zero for five of the first 6 years of sampling, indicating that at least 5 percent of the measurements were non-detects (2001 being the exception). After 2005, only one non-detect has been reported (2010).
- The 1-year average carbon tetrachloride concentrations vary by roughly $0.1 \mu\text{g}/\text{m}^3$ during the period from 2001 to 2007, even though the range of measurements varies. All of the statistical parameters exhibit an increase in magnitude from 2007 to 2008. 2008 is the first year that the 1-year average concentration is greater than $0.6 \mu\text{g}/\text{m}^3$; all of the 1-year averages between 2008 and 2013 are greater than $0.6 \mu\text{g}/\text{m}^3$.
- The difference between the 5th percentile and 95th percentile, or the range within which the majority of measurements fall, has been decreasing each year since 2005 and is at a minimum for 2013. Less than $0.25 \mu\text{g}/\text{m}^3$ separates these parameters for 2013.

Figure 20-33. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at ELNJ

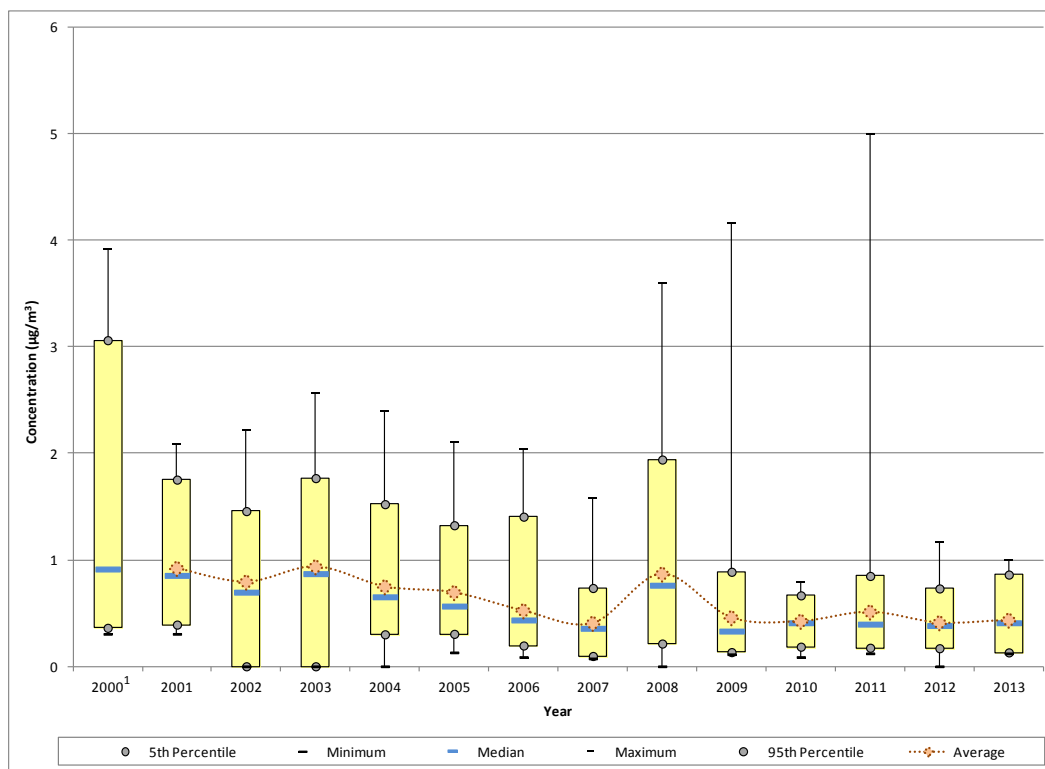


¹ A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 20-33 for 1,2-dichloroethane measurements collected at ELNJ include the following:

- There were no measured detections of 1,2-dichloroethane between 2000 and 2004. Between one and three measured detections were measured between 2005 and 2007, after which no measured detections were measured in 2008. After 2008, the number of measured detections increased significantly, from five in 2009, to 11 for 2010, 16 in 2011, and 55 for 2012. This explains the significant increase in the 1-year average concentrations shown for the later years of sampling.
- 2012 is the first year that the median concentration is greater than zero. Aside from the six non-detects, the range of measurements collected in 2012 is relatively small, ranging from 0.061 µg/m³ to 0.144 µg/m³. The 1-year average and median concentrations calculated for 2012 are approximately 0.0015 µg/m³ apart, indicating relatively little variability associated with the measurements collected in 2012.
- For 2013, the number of non-detects more than doubled (from six in 2012 to 14 in 2013), accounting for nearly one-quarter of the measurements collected. Yet, the 1-year average concentration changed little and the median concentration increased. Although the maximum concentration increased only slightly from 2012 to 2013, the number of 1,2-dichloroethane concentrations greater than 0.1 µg/m³ measured at ELNJ increased from seven in 2012 to 20 in 2013.

Figure 20-34. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at ELNJ



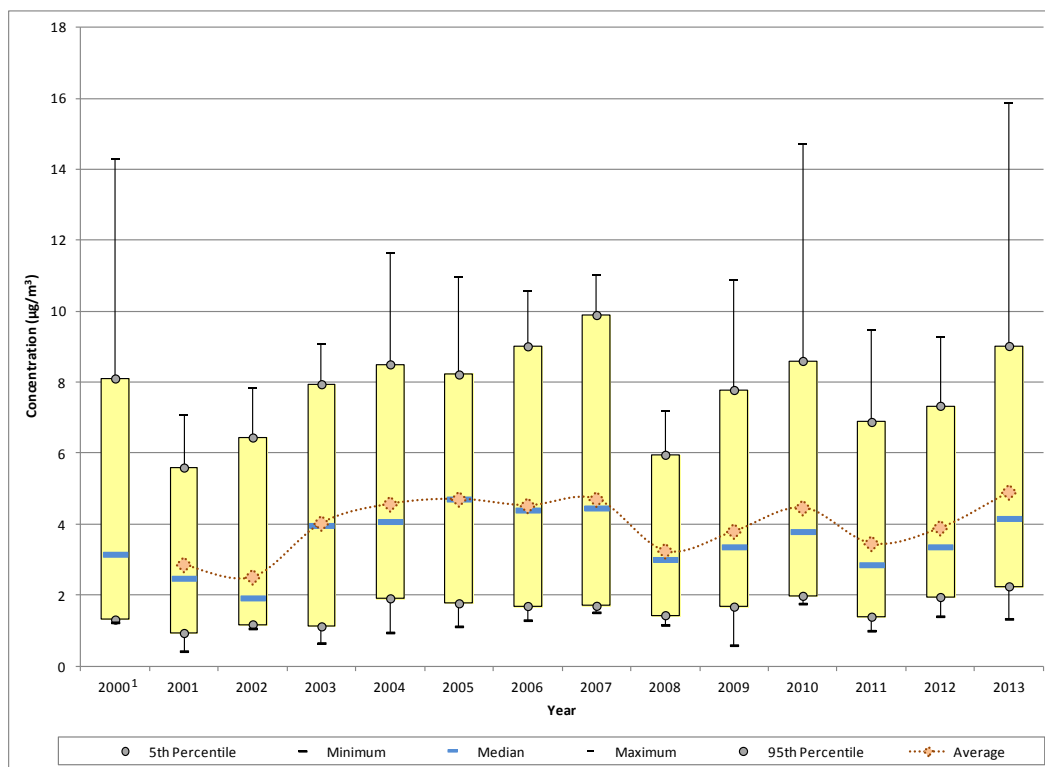
¹ A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 20-34 for ethylbenzene measurements collected at ELNJ include the following:

- The trends graph for ELNJ's ethylbenzene concentrations resembles the trends graph for ELNJ's benzene concentrations.
- There is an overall decreasing trend in the 1-year average and median concentrations between 2001 and 2007.
- A significant increase in the statistical parameters is shown for 2008. The median concentration for 2008 is greater than the 95th percentile for 2007. The number of ethylbenzene measurements greater than $1 \mu\text{g}/\text{m}^3$ increased from one in 2007 to 16 in 2008.
- The measurements collected in 2009 more closely resemble those collected in 2007 than 2008, with the exception of the maximum concentration measured.
- The smallest range of ethylbenzene measurements was collected in 2010, with all measurements collected spanning less than $0.75 \mu\text{g}/\text{m}^3$.

- Between 2009 and 2013, the majority of concentrations fell within a fairly similar range and the 1-year average concentrations did not change significantly, ranging from 0.41 $\mu\text{g}/\text{m}^3$ (2012) to 0.51 $\mu\text{g}/\text{m}^3$ (2011).

Figure 20-35. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at ELNJ



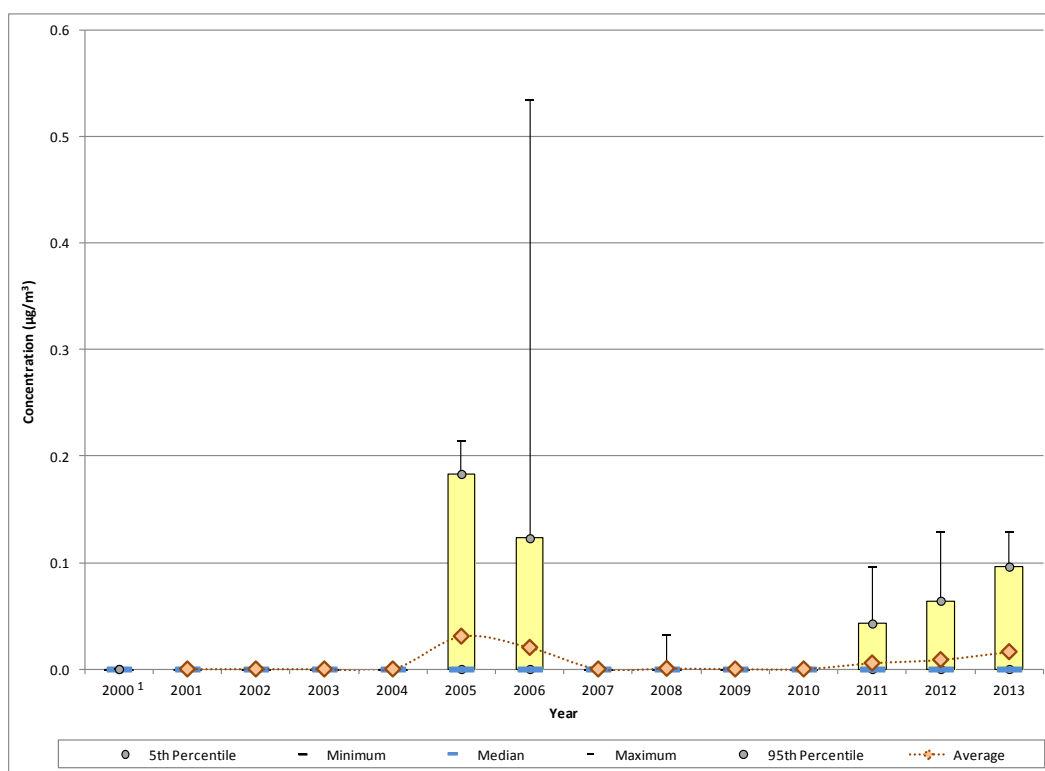
¹ A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 20-35 for formaldehyde measurements collected at ELNJ include the following:

- The maximum formaldehyde concentration was measured at ELNJ in 2013 (15.88 $\mu\text{g}/\text{m}^3$). A total of 14 concentrations greater than 10 $\mu\text{g}/\text{m}^3$ have been measured at ELNJ, with the most measured in 2007 (three).
- After a decreasing trend through 2002, there was a significant increase in formaldehyde concentrations from 2002 to 2003, as shown by the median concentration, which more than doubled, and the 1-year average concentration, which increased by roughly 60 percent. The number of formaldehyde concentrations greater than 4 $\mu\text{g}/\text{m}^3$ nearly tripled from 2002 to 2003 (from 9 to 25) while the number of measurements less than 2 $\mu\text{g}/\text{m}^3$ decreased by half (from 29 to 15).
- Between 2004 and 2007, there was relatively little change in the 1-year average concentrations of formaldehyde, which ranged from 4.52 $\mu\text{g}/\text{m}^3$ (2006) to 4.70 $\mu\text{g}/\text{m}^3$ (2005) during this time period.

- Similar to acetaldehyde, the 1-year average concentration of formaldehyde decreased significantly between 2007 and 2008, as the magnitude of concentrations measured decreased considerably. Afterward, an increasing trend is shown through 2010. While Figure 20-29 for acetaldehyde shows a continued increase for 2011 followed by a decrease for 2012, formaldehyde concentrations exhibit a decrease for 2011 followed by increases for 2012 and 2013. The 1-year average concentration of formaldehyde for ELNJ for 2013 is the highest 1-year average calculated since the onset of sampling.

Figure 20-36. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at ELNJ

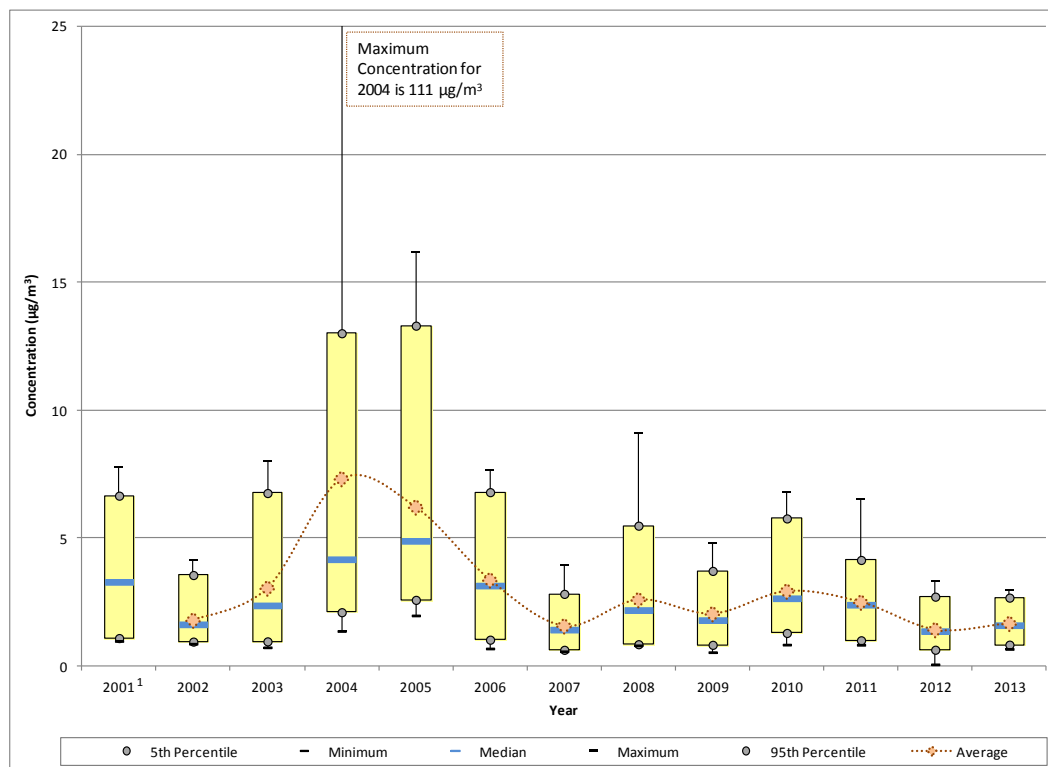


¹ A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 20-36 for hexachloro-1,3-butadiene measurements collected at ELNJ include the following:

- There were no measured detections of hexachloro-1,3-butadiene measured at ELNJ during the first 5 years of sampling.
- The number of measured detections increased to 13 for 2005, representing 22 percent of measurements, then decreased to five for 2006. Between 2007 and 2010, a single measured detection was measured (2008). Beginning in 2010, the number of measured detections began increasing again, from five for 2011 to seven for 2012, and 13 in 2013.

Figure 20-37. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at NBNJ



¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

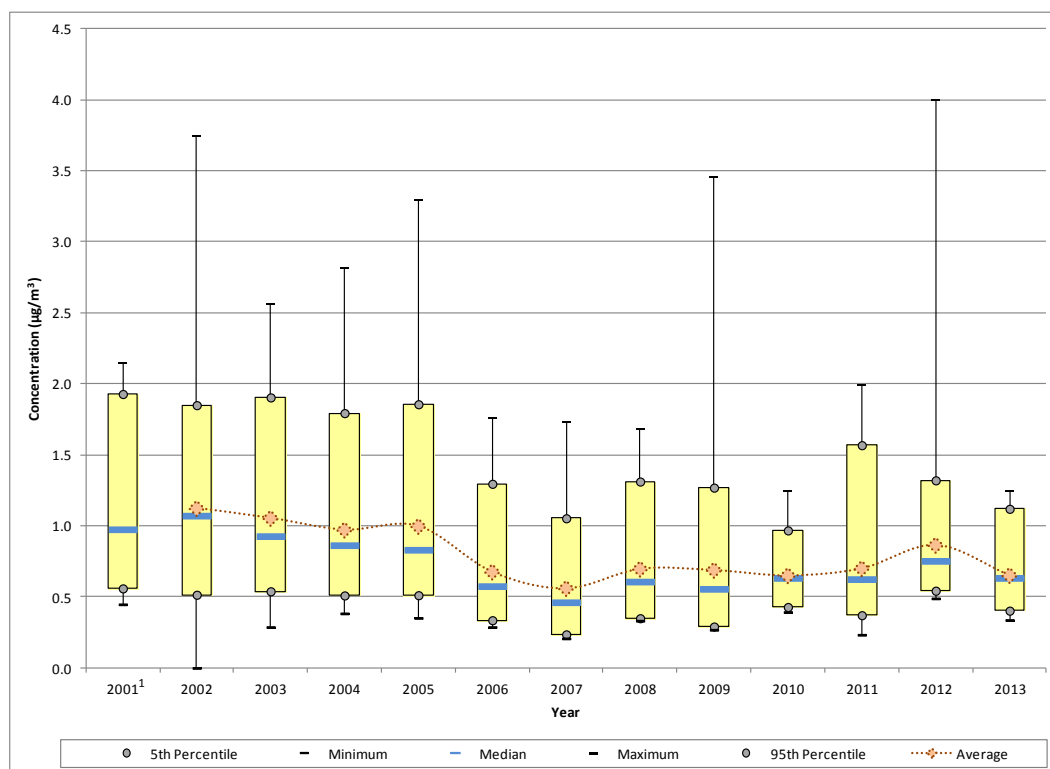
Observations from Figure 20-37 for acetaldehyde measurements collected at NBNJ include the following:

- Sampling for carbonyl compounds under the NMP began at NBNJ in May 2001. Because a full year's worth of data is not available for 2001, a 1-year average concentration is not presented, although the range of measurements is provided.
- The maximum acetaldehyde concentration was measured in 2004 (111 $\mu\text{g}/\text{m}^3$). This concentration is nearly seven times higher, and an order of magnitude higher, than the next highest concentration (16.2 $\mu\text{g}/\text{m}^3$, measured in 2005).
- Of the 29 concentrations greater than 8 $\mu\text{g}/\text{m}^3$, 28 were measured at NBNJ in 2004 or 2005 (the one other was measured in 2008). This, along with the outlier concentration measured in 2004, explains the significant increase in the statistical metrics shown from 2003 to 2004. Even without an outlier for 2005, most of the statistical metrics for 2005 exhibit slight increases from 2004 levels. The 1-year average concentration, however, does not. If the outlier was removed from the data set for 2004, the 1-year average concentration for 2004 would be less than the 1-year average concentration for 2005.
- The 1-year average concentration decreases significantly between 2005 and 2007, as do all of the other statistical parameters. This is followed by a significant increase in

the concentrations measured for 2008 as the range of concentrations measured doubled.

- Between 2008 and 2011, the 1-year average concentrations have an undulating pattern, fluctuating between 2 $\mu\text{g}/\text{m}^3$ and 3 $\mu\text{g}/\text{m}^3$.
- The concentrations decreased significantly for 2012, when the 1-year average concentration is at a minimum (1.41 $\mu\text{g}/\text{m}^3$).
- The smallest range of acetaldehyde concentrations was measured at NBNJ in 2013, although slight increases are shown for the 1-year average and median concentrations. Concentrations were higher overall in 2013 compared to 2012, although this is obscured somewhat by the compact range of concentrations measured. The minimum acetaldehyde concentration measured in 2012 is an order of magnitude less than the minimum concentration measured in 2013. Further, the number of measurements less than 1 $\mu\text{g}/\text{m}^3$ decreased from 17 in 2012 to eight in 2013. Differences are also evident at the upper end of the concentration range. Although the maximum concentration measured in 2013 is less than the maximum concentration measured in 2012, the number of concentrations greater than 2 $\mu\text{g}/\text{m}^3$ is higher for 2013: eight acetaldehyde concentrations greater than 2 $\mu\text{g}/\text{m}^3$ were measured in 2012 compared to 21 for 2013.

Figure 20-38. Yearly Statistical Metrics for Benzene Concentrations Measured at NBNJ

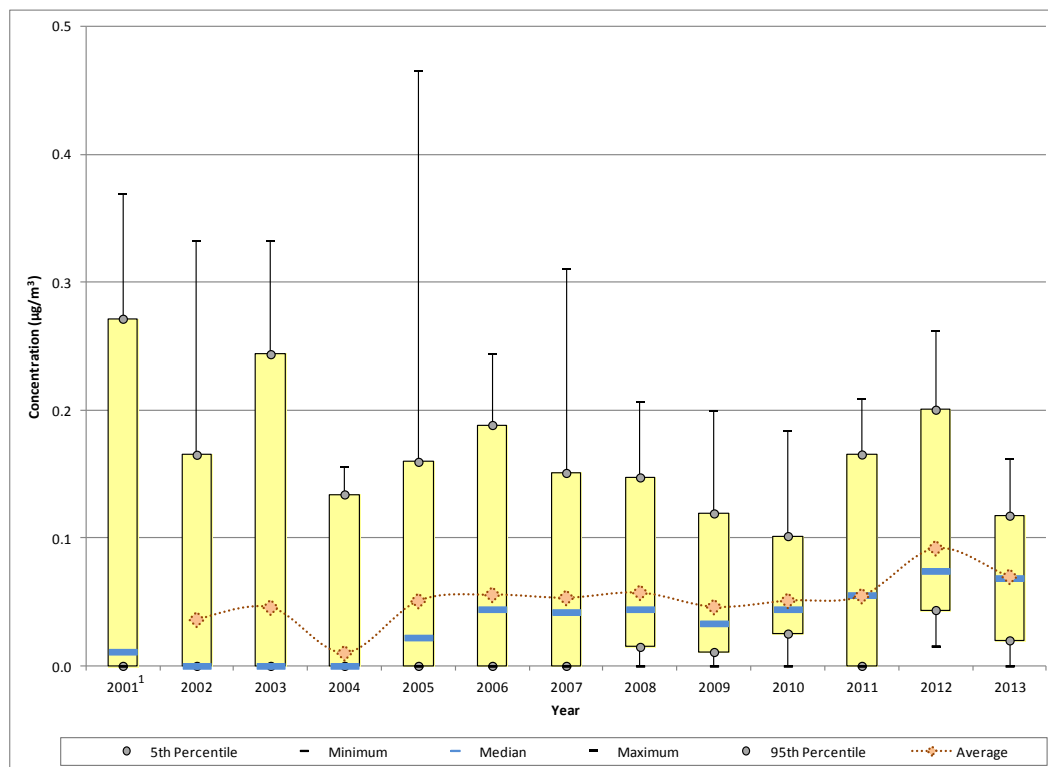


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 20-38 for benzene measurements collected at NBNJ include the following:

- Sampling for VOCs under the NMP also began at NBNJ in May 2001. Because a full year's worth of data is not available for 2001, a 1-year average concentration is not presented, although the range of measurements is provided.
- The maximum benzene concentration was measured in 2012 ($4.00 \mu\text{g}/\text{m}^3$); aside from this measurement, only three additional concentrations of benzene greater than $3 \mu\text{g}/\text{m}^3$ have been measured at NBNJ.
- Although a slight decreasing trend in the 1-year average concentration is shown between 2002 and 2004, a significant decrease is shown between 2005 and 2007, when both the median and 1-year average concentrations are at a minimum.
- Between 2008 and 2011, the 1-year average concentration is fairly static, ranging from $0.65 \mu\text{g}/\text{m}^3$ (2010) to $0.70 \mu\text{g}/\text{m}^3$ (2011), even though there is fluctuation in the range of concentrations measured.
- The 1-year average benzene concentration increased from 2011 to 2012, as did many of the statistical parameters, even though the majority of the measurements fell into a smaller range for 2012 than 2011. The minimum and 5th percentile increased considerably for 2012; there were 17 measurements in 2011 that are less than the minimum concentration measured in 2012 ($0.49 \mu\text{g}/\text{m}^3$). In addition, the number of measurements at the upper-end of the concentration increased substantially for 2012. In addition to a higher maximum concentration, the number of benzene measurements greater than $0.75 \mu\text{g}/\text{m}^3$ increased from 11 in 2011 to 31 in 2012, accounting for more than half of the measurements.
- The range of benzene concentrations measured at NBNJ in 2013 spans less than $1 \mu\text{g}/\text{m}^3$ and is very similar to the levels of benzene measured in 2010. The 1-year average concentration decreased significantly from 2012 to 2013 and is similar to the 1-year averages calculated for the period between 2008 and 2011.

Figure 20-39. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at NBNJ



¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

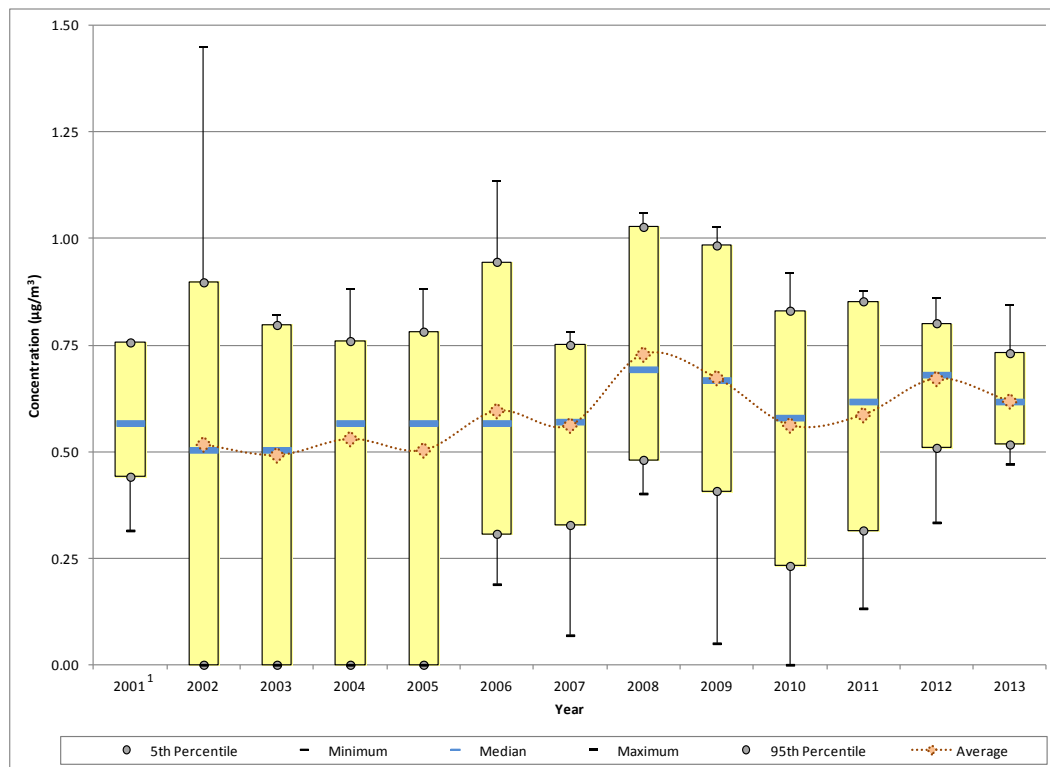
Observations from Figure 20-39 for 1,3-butadiene measurements collected at NBNJ include the following:

- The maximum 1,3-butadiene concentration was measured at NBNJ in 2005 ($0.47 \mu\text{g}/\text{m}^3$) and is the only measurement greater than $0.40 \mu\text{g}/\text{m}^3$ measured at NBNJ.
- The minimum, 5th percentile, and median concentrations are zero for 2002 through 2004. This indicates that at least half of the measurements were non-detects for these years. The median concentration increased from 2004 to 2005, indicating that the number of non-detects decreased, although the minimum and 5th percentile are still zero for 2005 through 2007. Further decreases in the number of non-detects are indicated by the 5th percentile increasing for 2008 through 2010. The number of non-detects increased considerably for 2011, from only two in 2010 to 17 for 2011, an increase that is evident from the return of the 5th percentile to zero for 2011. There were no non-detects measured in 2012, as indicated by the minimum concentration, which is greater than zero for the first time. Three non-detects were measured in 2013.
- The 1-year average concentration of 1,3-butadiene decreased significantly from 2003 to 2004. This is likely a result of the change in the number of non-detects as well as a reduction in the range of concentrations measured. The number of non-detects increased from 35 in 2003 to 56 in 2004 (accounting for more than 93 percent of the

samples collected in 2004). Thus, many zeros were substituted into this average. The increase in the 1-year average concentration shown from 2004 to 2005 results from a combination of fewer non-detects and a larger range of measurements. The number of non-detects decreased to 27 for 2005, accounting for fewer than half of the measurements for the first time.

- The 1-year average concentration exhibits little change between 2005 and 2011, ranging from 0.046 $\mu\text{g}/\text{m}^3$ (2009) to 0.057 $\mu\text{g}/\text{m}^3$ (2008).
- The 1-year average concentration increases significantly from 2011 to 2012. Increases are also exhibited by each of the other statistical parameters. This is largely due to the decrease in non-detects (and thus, zeroes substituted for non-detects in the calculations) from 17 non-detects in 2011 to zero for 2012. The number of concentrations at the upper end of the concentration range increased as well; the number of measurements greater than 0.1 $\mu\text{g}/\text{m}^3$ doubled, increasing from eight in 2011 to 18 in 2012.
- The 1,3-butadiene concentrations measured in 2013 decreased from 2012 levels but were still higher than those measured in the previous years. These two years have the only 1-year average and median concentrations greater than 0.06 $\mu\text{g}/\text{m}^3$.

Figure 20-40. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at NBNJ

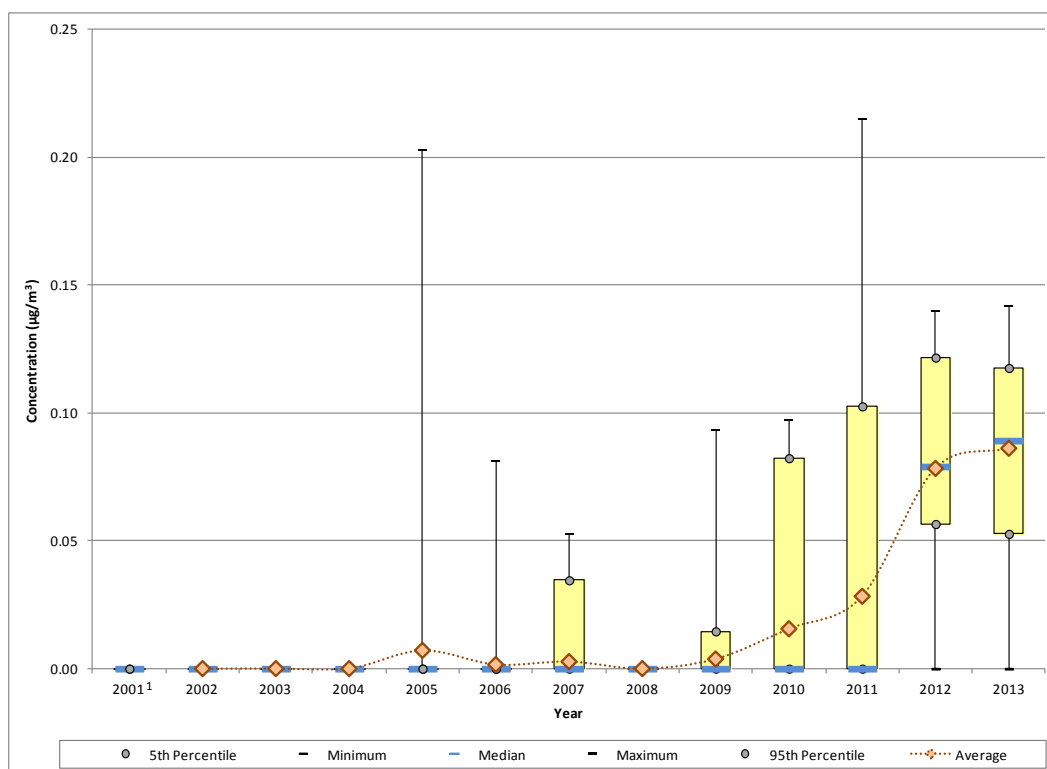


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 20-40 for carbon tetrachloride measurements collected at NBNJ include the following:

- The range of carbon tetrachloride measurements collected in 2001 was considerably smaller than those collected in the years immediately following. The considerable decrease in the minimum concentration shown for 2002 to 2005 is due to non-detects, which account for at least 5 percent of the measurements collected for each year during this time frame.
- The 1-year average concentration changed little between 2002 and 2005, ranging from $0.49 \mu\text{g}/\text{m}^3$ to $0.53 \mu\text{g}/\text{m}^3$. An increase in the 1-year average concentration is shown from 2005 to 2006, although the change is not statistically significant. This is a result of higher concentrations at both the lower and upper end of the concentration range. Between 2004 and 2007, the median concentration varied by only $0.003 \mu\text{g}/\text{m}^3$.
- All of the statistical parameters exhibit increases for 2008. The minimum concentration increased six-fold from 2007 to 2008. In addition, there were 20 measurements collected in 2008 that were greater than the maximum concentration measured in 2007.
- A decreasing trend in the measurements is shown after 2008 and continues through 2010. Even though the maximum concentrations continue to decrease for 2011 and 2012, and the differences between the 5th percentile and 95th percentile decrease each year, the 1-year average and median concentrations exhibit an increasing trend through 2012.
- Carbon tetrachloride concentrations measured in 2013 exhibit the least amount of variability. The smallest range of carbon tetrachloride concentrations was measured in 2013, the difference between the 5th and 95th percentiles is at a minimum, and the difference between the 1-year average and median concentrations is less than $0.001 \mu\text{g}/\text{m}^3$.

Figure 20-41. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at NBNJ

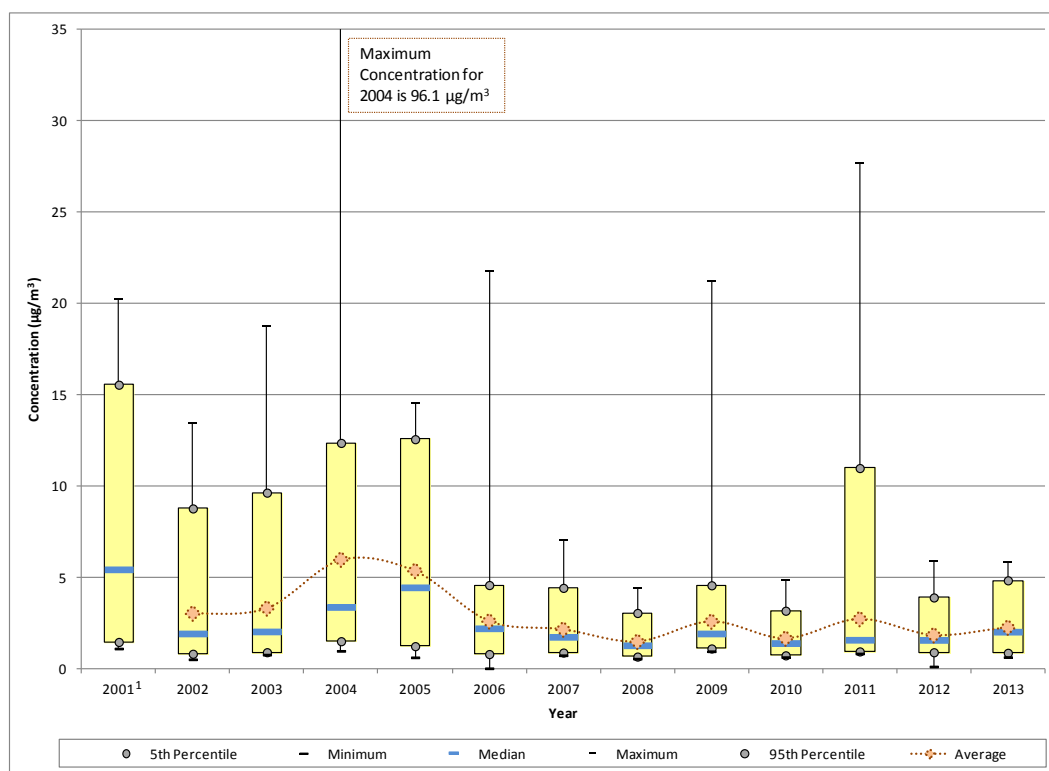


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 20-41 for 1,2-dichloroethane measurements collected at NBNJ include the following:

- There were no measured detections of 1,2-dichloroethane between 2001 and 2004. Between one and four measured detections were measured between 2005 and 2007, after which no measured detections were measured in 2008. After 2008, the number of measured detections increased significantly, from three in 2009, to 11 for 2010, 18 in 2011, 58 for 2012, and 59 in 2013. This increase in the number of measured detections is very similar to what was exhibited by the measurements collected at CHNJ and ELNJ. This also explains the significant increase in the 1-year average concentrations shown for the later years of sampling.
- 2012 is the first year that the median concentration is greater than zero. Aside from the two non-detects, the range of measurements collected in 2012 is relatively small, ranging from 0.053 $\mu\text{g}/\text{m}^3$ to 0.140 $\mu\text{g}/\text{m}^3$. The 1-year average and median concentrations calculated for 2012 are less than 0.001 $\mu\text{g}/\text{m}^3$ apart, indicating relatively little variability associated with the measurements collected in 2012. A similar observation can be made for 2013, although slight increases are shown for the 1-year average and median concentrations.

Figure 20-42. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at NBNJ



¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

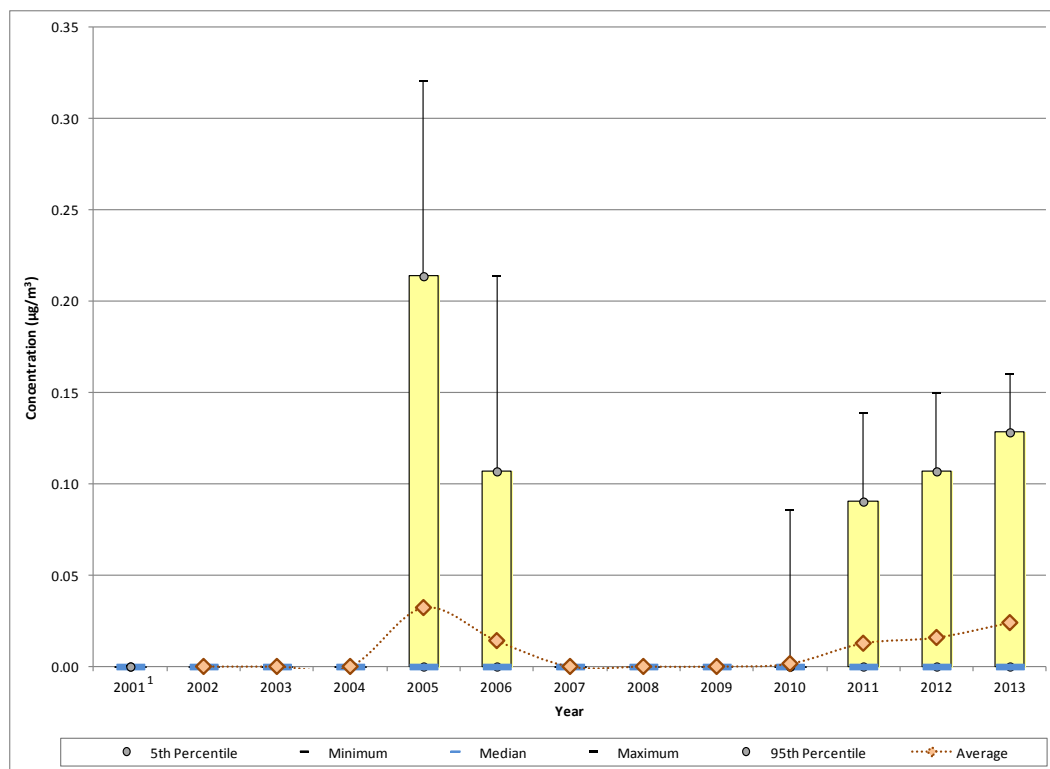
Observations from Figure 20-42 for formaldehyde measurements collected at NBNJ include the following:

- The maximum formaldehyde concentration ($96.1 \mu\text{g}/\text{m}^3$) was measured at NBNJ on the same day in 2004 that the highest acetaldehyde concentration was measured (August 31, 2004). This concentration of formaldehyde is more than three times the next highest concentration ($27.7 \mu\text{g}/\text{m}^3$, measured in 2011). Concentrations greater than $20 \mu\text{g}/\text{m}^3$ have been measured during five of the 13 years shown.
- After little change between 2002 and 2003, each of the statistical metrics exhibit increases from 2003 to 2004. This is due in part to the outlying measurement collected in 2004. If the maximum concentration was excluded from the calculations for 2004, the 1-year average concentration for 2004 would fall between those of 2003 and 2005, exhibiting lesser increases. However, concentrations were higher overall in 2004 compared to 2003 as the number of concentrations greater than $3 \mu\text{g}/\text{m}^3$ doubled from 2003 to 2004, from 17 to 34. At the lower end of the concentration range, five concentrations measured in 2003 are less than the minimum concentration measured in 2004.
- After 2005, concentrations of formaldehyde measured at NBNJ decreased significantly, with the 1-year average and median concentrations decreasing each year and reaching a minimum for 2008. This year also has the smallest range of

formaldehyde concentrations measured, although a similar range was also measured in 2010.

- Between 2008 and 2012, a year with more variability in the measurements alternates with a year with less variability. The measurements for 2011 exhibit a considerable amount of variability compared to the rest of the years within this period. The 95th percentile for 2011 is more than double the 95th percentile for the other years within this period. Yet, the median concentrations are nearly the same for 2011 and 2012.
- Most of the statistical parameters exhibit at least a slight increase for 2013. The minimum concentration measured in 2013 is an order of magnitude greater than minimum concentration measured in 2012. In addition, the number of formaldehyde concentrations greater than $2 \mu\text{g}/\text{m}^3$ measured at NBNJ in 2013 increased considerably, from 18 in 2012 to 33 in 2013, accounting for more than half of the measurements.

Figure 20-43. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at NBNJ



¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 20-43 for hexachloro-1,3-butadiene measurements collected at NBNJ include the following:

- There were no measured detections of hexachloro-1,3-butadiene measured during the first 4 years of sampling at NBNJ.
- The number of measured detections increased to nine for 2005, representing 16 percent of measurements, then decreased to five for 2006. The number of measured detections returned to zero between 2007 and 2009. A single measured detection was reported for 2010. The number of measured detections increased to eight for 2011, 11 for 2012, and 16 for 2013, the most since the onset of VOC sampling at NBNJ, accounting for roughly one-fourth of the measurements.

20.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at each New Jersey monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

20.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the New Jersey sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 20-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 20-6. Risk Approximations for the New Jersey Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$)⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Camden, New Jersey - CSNJ						
Acetaldehyde	0.0000022	0.009	59/59	2.78 ± 0.33	6.12	0.31
Benzene	0.0000078	0.03	57/57	0.85 ± 0.10	6.65	0.03
Bromomethane	--	0.005	53/57	0.52 ± 0.50	--	0.10
1,3-Butadiene	0.00003	0.002	56/57	0.10 ± 0.01	2.92	0.05
Carbon Tetrachloride	0.000006	0.1	57/57	0.61 ± 0.03	3.65	0.01
1,2-Dichloroethane	0.000026	2.4	53/57	0.09 ± 0.01	2.33	<0.01
Ethylbenzene	0.0000025	1	57/57	0.31 ± 0.04	0.76	<0.01
Formaldehyde	0.000013	0.0098	59/59	4.96 ± 0.59	64.54	0.51
Hexachloro-1,3-butadiene	0.000022	0.09	15/57	0.02 ± 0.01	0.48	<0.01
Propionaldehyde	--	0.008	59/59	0.60 ± 0.07	--	0.07
Chester, New Jersey - CHNJ						
Acetaldehyde	0.0000022	0.009	61/61	1.31 ± 0.15	2.88	0.15
Benzene	0.0000078	0.03	61/61	0.49 ± 0.09	3.84	0.02
1,3-Butadiene	0.00003	0.002	46/61	0.04 ± 0.01	1.17	0.02
Carbon Tetrachloride	0.000006	0.1	61/61	0.61 ± 0.02	3.67	0.01
1,2-Dichloroethane	0.000026	2.4	54/61	0.08 ± 0.01	1.97	<0.01
Formaldehyde	0.000013	0.0098	61/61	2.14 ± 0.34	27.82	0.22
Hexachloro-1,3-butadiene	0.000022	0.09	14/61	0.02 ± 0.01	0.45	<0.01

-- = A Cancer URE or Noncancer RfC is not available.

Table 20-6. Risk Approximations for the New Jersey Monitoring Sites (Continued)

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	0.0000022	0.009	61/61	2.60 ± 0.26	5.72	0.29
Benzene	0.0000078	0.03	61/61	0.81 ± 0.07	6.28	0.03
1,3-Butadiene	0.00003	0.002	61/61	0.11 ± 0.01	3.42	0.06
Carbon Tetrachloride	0.000006	0.1	61/61	0.63 ± 0.02	3.76	0.01
1,2-Dichloroethane	0.000026	2.4	47/61	0.07 ± 0.01	1.93	<0.01
Ethylbenzene	0.0000025	1	61/61	0.43 ± 0.06	1.08	<0.01
Formaldehyde	0.000013	0.0098	61/61	4.90 ± 0.67	63.67	0.50
Hexachloro-1,3-butadiene	0.000022	0.09	13/61	0.02 ± 0.01	0.36	<0.01
North Brunswick, New Jersey - NBNJ						
Acetaldehyde	0.0000022	0.009	62/62	1.66 ± 0.15	3.64	0.18
Benzene	0.0000078	0.03	61/61	0.65 ± 0.05	5.08	0.02
1,3-Butadiene	0.00003	0.002	58/61	0.07 ± 0.01	2.10	0.03
Carbon Tetrachloride	0.000006	0.1	61/61	0.62 ± 0.02	3.71	0.01
1,2-Dichloroethane	0.000026	2.4	59/61	0.09 ± 0.01	2.24	<0.01
Formaldehyde	0.000013	0.0098	62/62	2.24 ± 0.30	29.15	0.23
Hexachloro-1,3-butadiene	0.000022	0.09	16/61	0.02 ± 0.01	0.53	<0.01

-- = A Cancer URE or Noncancer RfC is not available.

Observations from Table 20-6 include the following:

- For CSNJ, the pollutants with the highest annual average concentrations are formaldehyde, acetaldehyde, and benzene. Formaldehyde has the highest cancer risk approximation for this site (64.54 in-a-million), followed by benzene and acetaldehyde. The cancer risk approximation for formaldehyde is at least an order of magnitude higher than the cancer risk approximations for the other pollutants of interest for CSNJ. CSNJ's cancer risk approximation for formaldehyde is the highest cancer risk approximation among the pollutants of interest for the New Jersey sites and the fourth highest among all NMP sites. None of the pollutants of interest for CSNJ have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants.

Formaldehyde is the pollutant with the highest noncancer hazard approximation for CSNJ (0.51).

- For CHNJ, the pollutants with the highest annual average concentrations are formaldehyde, acetaldehyde, and carbon tetrachloride. Formaldehyde has the highest cancer risk approximation for this site (27.82 in-a-million), followed by benzene and carbon tetrachloride. The cancer risk approximation for formaldehyde is at least an order of magnitude higher than the approximations for the other pollutants of interest for CHNJ. None of the pollutants of interest for CHNJ have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. Formaldehyde is the pollutant with the highest noncancer hazard approximation for CHNJ (0.22).
- For ELNJ, the pollutants with the highest annual average concentrations are formaldehyde, acetaldehyde, and benzene. These three pollutants also have the highest cancer risk approximations for this site, although the cancer risk approximation for benzene is greater than the cancer risk approximation for acetaldehyde. ELNJ's cancer risk approximation for formaldehyde (63.67 in-a-million) is similar to the cancer risk approximation calculated for CSNJ and is the fifth highest cancer risk approximation among all NMP sites. None of the pollutants of interest for ELNJ have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. Formaldehyde is the pollutant with the highest noncancer hazard approximation for ELNJ (0.50).
- For NBNJ, the pollutants with the highest annual average concentrations are formaldehyde, acetaldehyde, and benzene. Formaldehyde has the highest cancer risk approximation for NBNJ (29.15 in-a-million), followed by benzene and carbon tetrachloride. None of the pollutants of interest for NBNJ have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. Formaldehyde is the pollutant with the highest noncancer hazard approximation for NBNJ (0.23).

20.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 20-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 20-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 20-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each New Jersey site, as presented in Table 20-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 20-7. Table 20-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 20.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 20-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the New Jersey Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Camden, New Jersey (Camden County) - CSNJ					
Benzene	130.73	Formaldehyde	1.24E-03	Formaldehyde	64.54
Formaldehyde	95.20	Benzene	1.02E-03	Benzene	6.65
Ethylbenzene	64.14	1,3-Butadiene	6.27E-04	Acetaldehyde	6.12
Acetaldehyde	55.11	Naphthalene	3.58E-04	Carbon Tetrachloride	3.65
1,3-Butadiene	20.89	POM, Group 2b	2.36E-04	1,3-Butadiene	2.92
Tetrachloroethylene	11.72	Nickel, PM	2.02E-04	1,2-Dichloroethane	2.33
Naphthalene	10.52	POM, Group 2d	1.65E-04	Ethylbenzene	0.76
POM, Group 2b	2.68	Ethylbenzene	1.60E-04	Hexachloro-1,3-butadiene	0.48
POM, Group 2d	1.87	Arsenic, PM	1.38E-04		
Trichloroethylene	1.20	POM, Group 5a	1.23E-04		
Chester, New Jersey (Morris County) - CHNJ					
Benzene	161.55	Benzene	1.26E-03	Formaldehyde	27.82
Formaldehyde	95.57	Formaldehyde	1.24E-03	Benzene	3.84
Ethylbenzene	86.05	1,3-Butadiene	7.62E-04	Carbon Tetrachloride	3.67
Acetaldehyde	58.64	Naphthalene	3.43E-04	Acetaldehyde	2.88
1,3-Butadiene	25.41	Ethylbenzene	2.15E-04	1,2-Dichloroethane	1.97
Tetrachloroethylene	11.82	POM, Group 2b	2.05E-04	1,3-Butadiene	1.17
Naphthalene	10.09	Nickel, PM	1.97E-04	Hexachloro-1,3-butadiene	0.45
Dichloromethane	5.27	POM, Group 2d	1.45E-04		
POM, Group 2b	2.33	POM, Group 5a	1.31E-04		
POM, Group 2d	1.64	Arsenic, PM	1.30E-04		

Table 20-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the New Jersey Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Elizabeth, New Jersey (Union County) - ELNJ					
Benzene	138.53	Formaldehyde	1.30E-03	Formaldehyde	63.67
Formaldehyde	99.64	Benzene	1.08E-03	Benzene	6.28
Ethylbenzene	74.03	1,3-Butadiene	6.29E-04	Acetaldehyde	5.72
Acetaldehyde	59.30	Nickel, PM	4.27E-04	Carbon Tetrachloride	3.76
1,3-Butadiene	20.96	Naphthalene	3.75E-04	1,3-Butadiene	3.42
Tetrachloroethylene	14.36	Arsenic, PM	2.03E-04	1,2-Dichloroethane	1.93
Naphthalene	11.04	Ethylbenzene	1.85E-04	Ethylbenzene	1.08
Dichloromethane	2.96	POM, Group 2b	1.84E-04	Hexachloro-1,3-butadiene	0.36
POM, Group 2b	2.09	Hexavalent Chromium	1.55E-04		
Trichloroethylene	1.77	POM, Group 2d	1.33E-04		
North Brunswick, New Jersey (Middlesex County) - NBNJ					
Benzene	213.63	Formaldehyde	1.81E-03	Formaldehyde	29.15
Formaldehyde	139.48	Benzene	1.67E-03	Benzene	5.08
Ethylbenzene	110.60	1,3-Butadiene	9.59E-04	Carbon Tetrachloride	3.71
Acetaldehyde	83.83	Naphthalene	5.42E-04	Acetaldehyde	3.64
1,3-Butadiene	31.96	Hydrazine	4.38E-04	1,2-Dichloroethane	2.24
Tetrachloroethylene	24.38	POM, Group 2b	2.82E-04	1,3-Butadiene	2.10
Naphthalene	15.95	Ethylbenzene	2.77E-04	Hexachloro-1,3-butadiene	0.53
POM, Group 2b	3.20	POM, Group 2d	2.03E-04		
Trichloroethylene	3.19	Arsenic, PM	1.86E-04		
Dichloromethane	3.03	POM, Group 5a	1.85E-04		

Table 20-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the New Jersey Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Camden, New Jersey (Camden County) - CSNJ					
Toluene	422.02	Acrolein	598,846.68	Formaldehyde	0.51
Hexane	272.19	1,3-Butadiene	10,445.69	Acetaldehyde	0.31
Xylenes	249.52	Formaldehyde	9,713.82	Bromomethane	0.10
Benzene	130.73	Acetaldehyde	6,122.91	Propionaldehyde	0.07
Formaldehyde	95.20	Nickel, PM	4,680.35	1,3-Butadiene	0.05
Ethylbenzene	64.14	Benzene	4,357.53	Benzene	0.03
Acetaldehyde	55.11	Naphthalene	3,506.47	Carbon Tetrachloride	0.01
Methyl isobutyl ketone	32.86	Xylenes	2,495.17	Ethylbenzene	<0.01
Hydrochloric acid	29.17	Arsenic, PM	2,139.62	Hexachloro-1,3-butadiene	<0.01
1,3-Butadiene	20.89	Cadmium, PM	1,996.78	1,2-Dichloroethane	<0.01
Chester, New Jersey (Morris County) - CHNJ					
Toluene	528.02	Acrolein	251,595.35	Formaldehyde	0.22
Xylenes	342.26	1,3-Butadiene	12,707.28	Acetaldehyde	0.15
Hexane	314.43	Formaldehyde	9,751.59	1,3-Butadiene	0.02
Benzene	161.55	Acetaldehyde	6,515.84	Benzene	0.02
Formaldehyde	95.57	Benzene	5,385.08	Carbon Tetrachloride	0.01
Ethylbenzene	86.05	Nickel, PM	4,561.47	Hexachloro-1,3-butadiene	<0.01
Ethylene glycol	81.36	Xylenes	3,422.56	1,2-Dichloroethane	<0.01
Acetaldehyde	58.64	Naphthalene	3,363.00		
Methyl isobutyl ketone	44.35	Lead, PM	2,402.90		
Methanol	38.69	Arsenic, PM	2,017.68		

Table 20-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the New Jersey Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Elizabeth, New Jersey (Union County) - ELNJ					
Toluene	482.50	Acrolein	306,476.99	Formaldehyde	0.50
Hexane	351.57	Cyanide Compounds, PM	37,500.01	Acetaldehyde	0.29
Xylenes	279.98	1,3-Butadiene	10,478.70	1,3-Butadiene	0.06
Benzene	138.53	Formaldehyde	10,167.13	Benzene	0.03
Formaldehyde	99.64	Nickel, PM	9,894.58	Carbon Tetrachloride	0.01
Ethylbenzene	74.03	Acetaldehyde	6,588.93	Ethylbenzene	<0.01
Acetaldehyde	59.30	Benzene	4,617.66	Hexachloro-1,3-butadiene	<0.01
Ethylene glycol	45.18	Chlorine	4,370.00	1,2-Dichloroethane	<0.01
Methyl isobutyl ketone	44.98	Naphthalene	3,678.63		
Cyanide Compounds, PM	30.00	Lead, PM	3,167.18		
North Brunswick, New Jersey (Middlesex County) - NBNJ					
Toluene	721.66	Acrolein	424,778.44	Formaldehyde	0.23
Hexane	499.90	1,3-Butadiene	15,980.24	Acetaldehyde	0.18
Xylenes	432.41	Formaldehyde	14,232.86	1,3-Butadiene	0.03
Benzene	213.63	Acetaldehyde	9,314.11	Benzene	0.02
Formaldehyde	139.48	Benzene	7,120.91	Carbon Tetrachloride	0.01
Ethylbenzene	110.60	Naphthalene	5,317.45	Hexachloro-1,3-butadiene	<0.01
Acetaldehyde	83.83	Lead, PM	5,099.62	1,2-Dichloroethane	<0.01
Methyl isobutyl ketone	58.79	Titanium tetrachloride	4,535.00		
Ethylene glycol	35.26	Xylenes	4,324.07		
1,3-Butadiene	31.96	Arsenic, PM	2,886.75		

Observations from Table 20-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in all four New Jersey counties.
- Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for all four New Jersey counties, although the order is different for Morris County (CHNJ).
- Six of the 10 highest emitted pollutants in Union and Middlesex Counties also have the highest toxicity-weighted emissions. Seven of the highest emitted pollutants in Camden and Morris Counties also have the highest toxicity-weighted emissions.
- Formaldehyde, benzene, ethylbenzene, and 1,3-butadiene are among the pollutants with the highest cancer risk approximations for CSNJ and also appear on both emissions-based lists. Acetaldehyde is also among the pollutants with the highest cancer risk approximations for CSNJ; this pollutant also appears among the highest emitted pollutants in Camden County but does not appear among those with the highest toxicity-weighted emissions. These observations are also true for ELNJ.
- Formaldehyde, benzene, and 1,3-butadiene are among the pollutants with the highest cancer risk approximations for CHNJ and also appear on both emissions-based lists. Acetaldehyde is also among the pollutants with the highest cancer risk approximations for CHNJ; this pollutant also appears among the highest emitted pollutants in Morris County but does not appear among those with the highest toxicity-weighted emissions. These observations are also true for NBNJ.
- Carbon tetrachloride, 1,2-dichloroethane, and hexachloro-1,3-butadiene are among the pollutants with the highest cancer risk approximations for each New Jersey site. Yet these pollutants do not appear on either emissions-based list for any of the four counties.
- Arsenic and several POM Groups appear among the pollutants with the highest toxicity-weighted emissions for each New Jersey county with an NMP site. Neither speciated metals nor PAHs were sampled for under the NMP.

Observations from Table 20-8 include the following:

- Toluene, hexane, and xylenes are the highest emitted pollutants with noncancer RfCs in Camden, Union, and Middlesex Counties. In Morris County (CHNJ), toluene is also the highest emitted pollutant, but the xylenes emissions are greater than the hexane emissions.
- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for all four New Jersey counties but is not among the highest emitted pollutants for any of the New Jersey counties (acrolein ranks between 11th and 17th for these counties). Although acrolein was sampled for at all four sites, this pollutant was excluded from the pollutant of interest designation, and thus

subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. 1,3-Butadiene and formaldehyde are the pollutants with the second and third highest toxicity-weighted emissions in three of the four counties. For Union County (ELNJ), cyanide compounds rank higher than 1,3-butadiene and formaldehyde for this county's toxicity-weighted emissions.

- Between four and five of the 10 highest emitted pollutants also have the highest toxicity-weighted emissions for each of the New Jersey counties.
- Formaldehyde, acetaldehyde, and benzene are pollutants of interest for all four New Jersey sites and appear on both emissions-based lists for their respective counties. 1,3-Butadiene, another pollutant of interest for all four sites, appears among those with the highest toxicity-weighted emissions for all four counties, but does not rank among the highest emitted in Morris County (CHNJ) or Union County (ELNJ). Ethylbenzene, a pollutant of interest for CSNJ and ELNJ, appears among the highest emitted pollutants (with a noncancer RfC) but not among those with the highest toxicity-weighted emissions.
- Carbon tetrachloride, 1,2-dichloroethane, and hexachloro-1,3-butadiene are among the pollutants with the highest noncancer hazard approximations for each site. Yet these pollutants do not appear on either emissions-based list for any of the New Jersey counties. Bromomethane and propionaldehyde, pollutants of interest for CSNJ, appear on neither emissions-based list for Camden County.
- Several speciated metals and naphthalene appear among the pollutants with the highest toxicity-weighted emissions for each New Jersey county with an NMP site. Neither speciated metals nor PAHs were sampled for under the NMP.

20.6 Summary of the 2013 Monitoring Data for the New Jersey Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *Sixteen pollutants failed at least one screen for CSNJ; nine failed screens for CHNJ; 11 failed screens for ELNJ; and 11 failed screens for NBNJ.*
- ❖ *Formaldehyde and acetaldehyde had the highest annual average concentrations for each of the New Jersey sites.*
- ❖ *NBNJ has the third highest annual average concentration of hexachloro-1,3-butadiene among NMP sites sampling VOCs, with the annual averages for CSNJ and CHNJ ranking fifth and sixth, respectively. CSNJ has the third highest annual average concentrations of both acetaldehyde and formaldehyde among NMP sites sampling carbonyl compounds.*

- ❖ *ELNJ is the longest running NMP site still participating in the program. Concentrations of benzene have decreased significantly at this site since the onset of sampling. This is also true of ethylbenzene, although concentrations have leveled out in the last few years. The detection rates of 1,2-dichloroethane and hexachloro-1,3-butadiene at CHNJ, ELNJ, and NBNJ have been increasing steadily over the last few years of sampling.*
- ❖ *Formaldehyde has the highest cancer risk approximations of the pollutants of interest for each of the New Jersey sites. None of the site-specific pollutants of interest have noncancer hazard approximations greater than an HQ of 1.0.*

21.0 Sites in New York

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS sites in New York, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

21.1 Site Characterization

This section characterizes the New York monitoring sites by providing geographical and physical information about the locations of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

One New York monitoring site is located in New York City (BXNY) and one is located in Rochester (ROCH). Figure 21-1 is a composite satellite image retrieved from ArcGIS Explorer showing the New York City monitoring site and its immediate surroundings. Figure 21-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of BXNY are included in the facility counts provided in Figure 21-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources just within the boundary. Figures 21-3 and 21-4 are the composite satellite image and emissions sources map for ROCH. Table 21-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 21-1. New York City, New York (BXNY) Monitoring Site

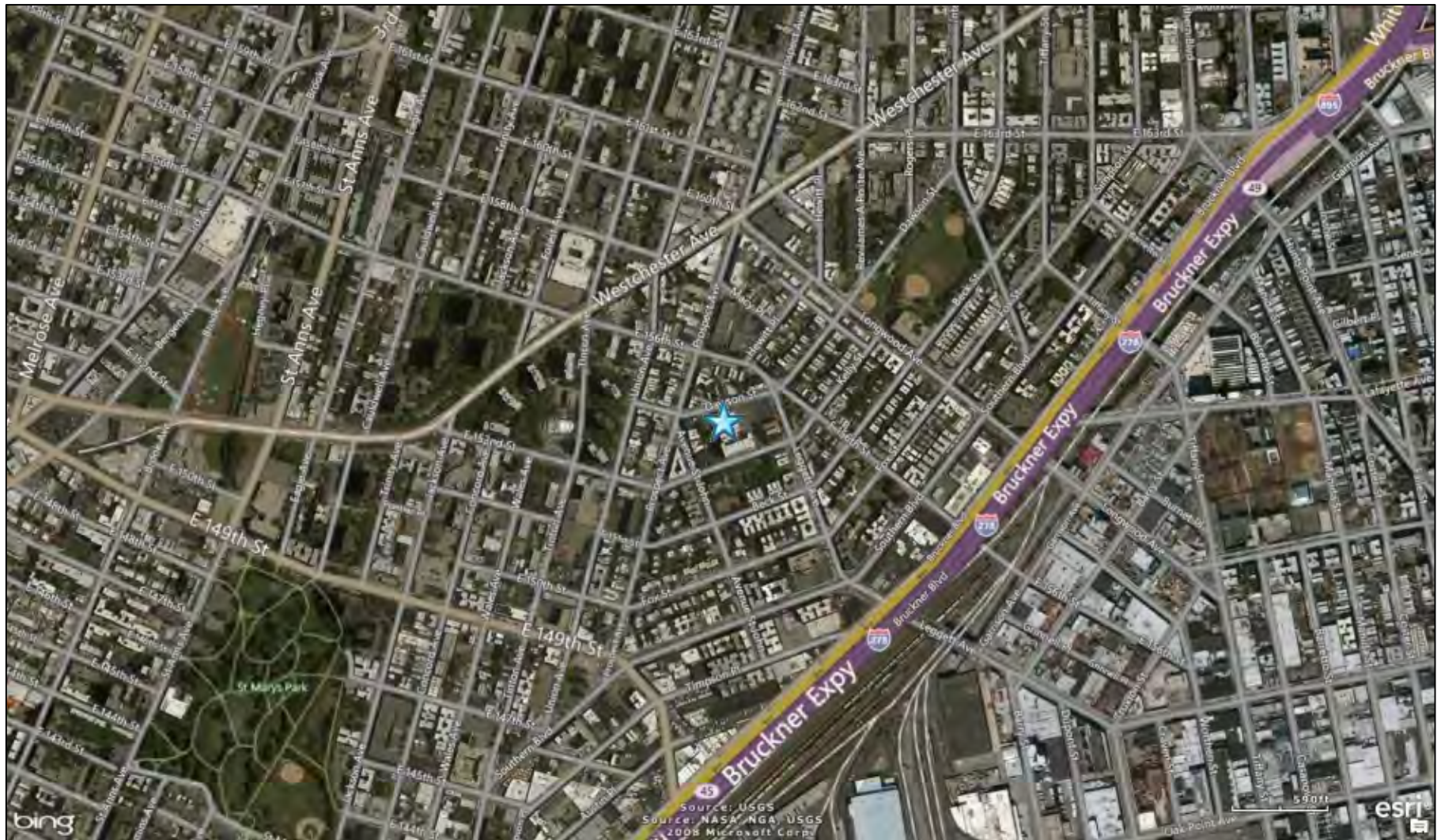


Figure 21-2. NEI Point Sources Located Within 10 Miles of BXNY

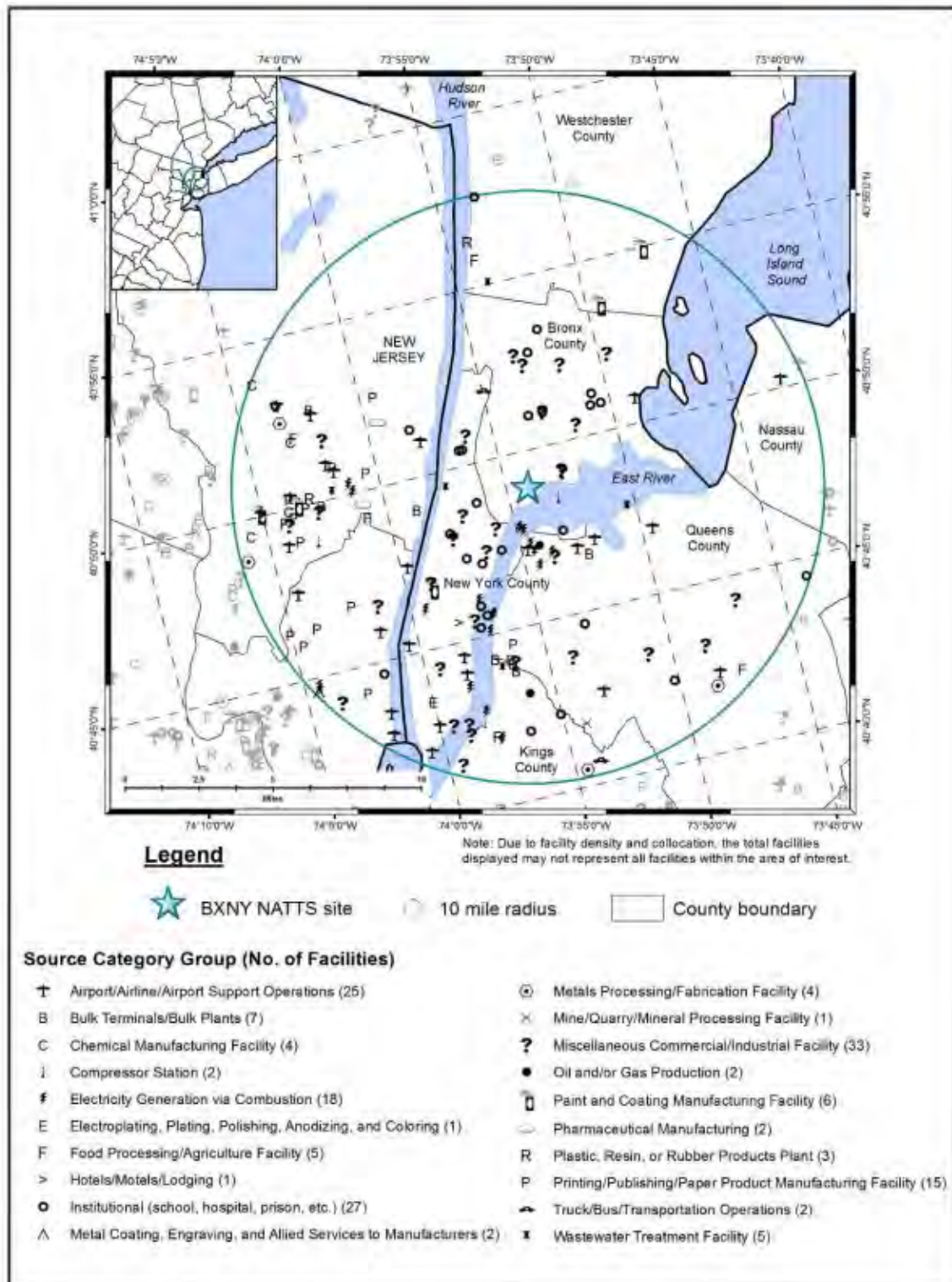


Figure 21-3. Rochester, New York (ROCH) Monitoring Site

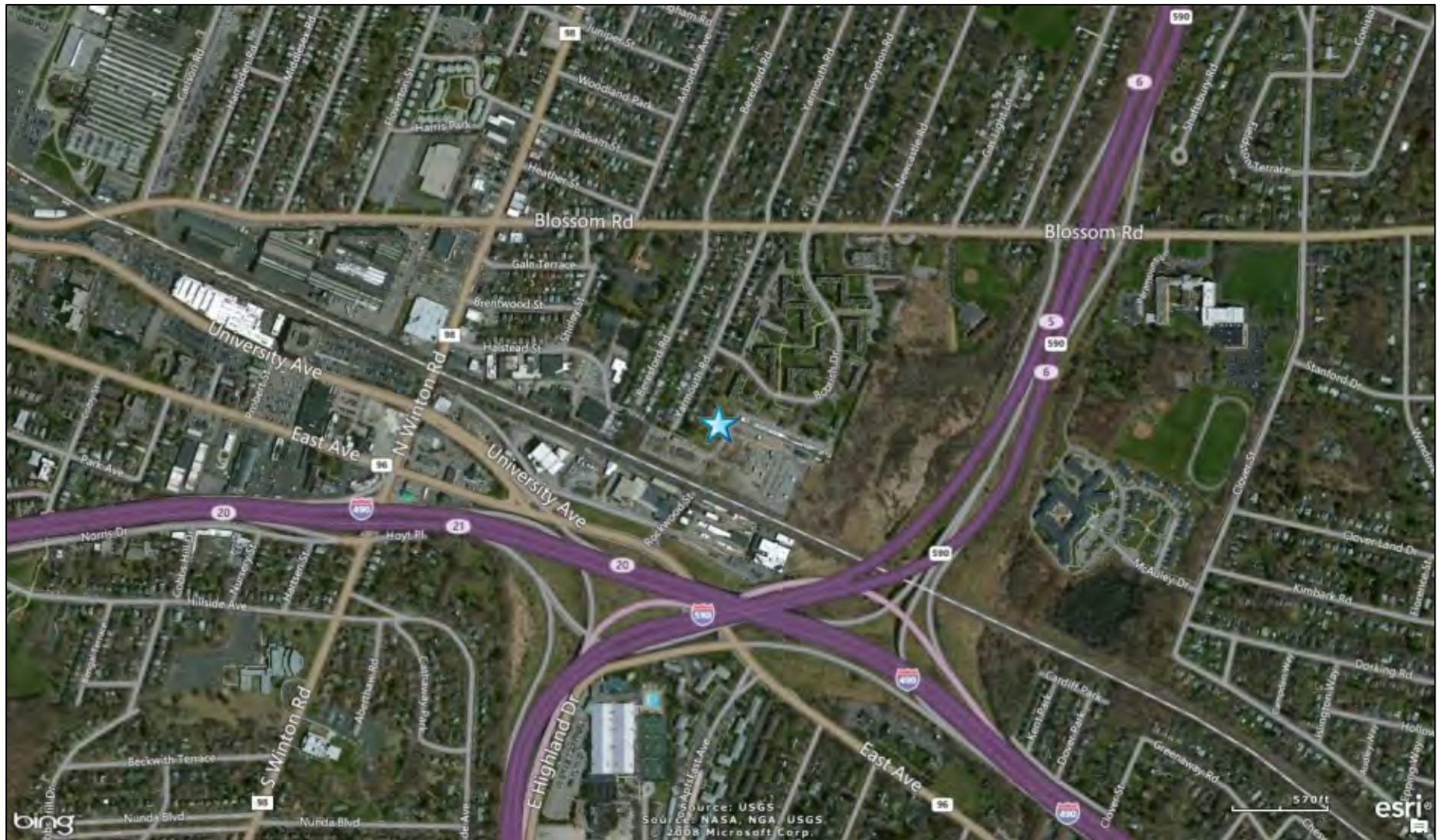


Figure 21-4. NEI Point Sources Located Within 10 Miles of ROCH

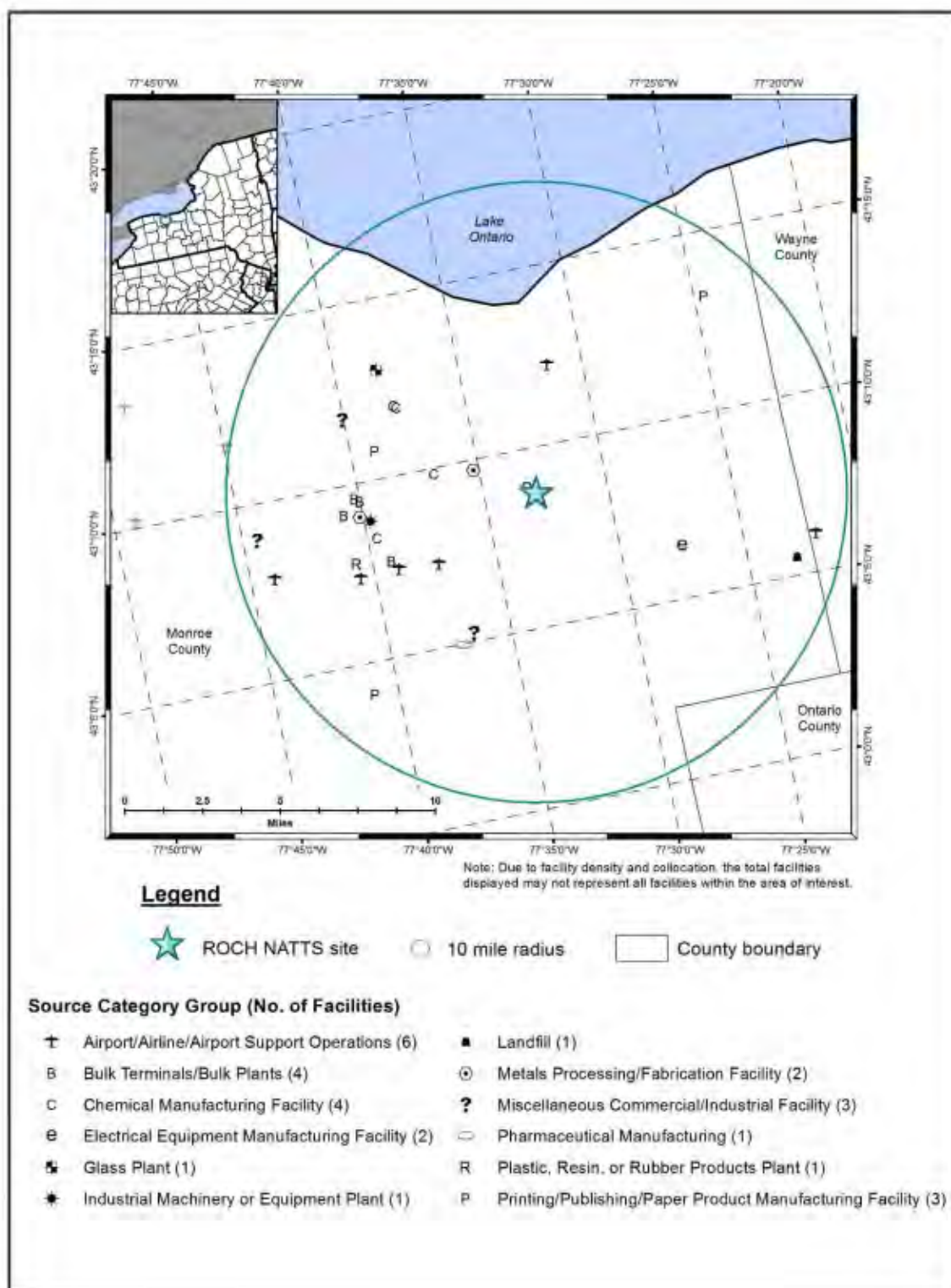


Table 21-1. Geographical Information for the New York Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>BXNY</i>	36-005-0110	New York	Bronx	New York-Newark-Jersey City, NY-NJ-PA	40.81618, -73.902	Residential	Urban/City Center	Haze, SO ₂ , NO, NO ₂ , NO _x , VOCs, Carbonyl compounds, O ₃ , Meteorological Parameters, PM coarse, Black Carbon, PM ₁₀ , PM ₁₀ Speciation, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
<i>ROCH</i>	36-055-1007	Rochester	Monroe	Rochester, NY	43.14618, -77.54817	Residential	Urban/City Center	CO, SO ₂ , NO, NO ₂ , NO _y , VOCs, Carbonyl compounds, O ₃ , Meteorological parameters, Black Carbon, PM ₁₀ , PM ₁₀ Speciation, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

BXNY is located on the property of Public School 52 (PS 52) in the Bronx Borough of New York City, northeast of Manhattan. The site was established in 1999 and is considered one of the premier particulate sampling sites in New York City and is the Bronx (#1) NATTS site. The surrounding area is urban and residential, as shown in Figure 21-1. The Bruckner Expressway (I-278) is located a few blocks east of the monitoring site and other heavily traveled roadways are also located within a few miles of the site. A freight yard and other industries lie on the southeast and south side of I-278, part of which can be seen in the lower right-hand side of Figure 21-1. BXNY is less than one-half mile from the East River at its closest point.

Figure 21-2 shows the numerous point sources that are located within 10 miles of BXNY, with a majority of the emissions sources located to the south and west of the site. The source categories with the greatest number of emissions sources surrounding the site include institutions such as hospitals, schools, and prisons; airport and airport support operations, which include airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; electricity generation via combustion; and printing, publishing, and paper product manufacturing. The point source closest to BXNY is a compressor station.

ROCH is located at a power substation on the east side of Rochester, in western New York. Rochester is approximately halfway between Syracuse and Buffalo, with Lake Ontario situated to the north. Although the area north and west of the site is primarily residential, as shown in Figure 21-3, a railroad transverses the area just south of the site, and I-590 and I-490 intersect farther south with commercial areas adjacent to this corridor. The site is used by researchers from several universities for short-term air monitoring studies and is the Rochester NATTS site. As Figure 21-4 shows, the relatively few point sources within 10 miles of ROCH are located primarily on the west side of the 10-mile boundary. The airport and airport support operations source category is the source category with the greatest number of emissions sources surrounding ROCH, although there are also bulk plants/bulk terminals, chemical manufacturers, metals processors/fabricators, and printing, publishing, and paper product manufacturers nearby, to name a few. The closest source to ROCH is an electrical equipment manufacturer.

Table 21-2 presents additional site-characterizing information, including indicators of mobile source activity, for the New York monitoring sites. Table 21-2 includes both county-level population and vehicle registration information. Table 21-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 21-2 presents the county-level daily VMT for Bronx and Monroe Counties from the 2011 NEI.

Table 21-2. Population, Motor Vehicle, and Traffic Information for the New York Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
<i>BXNY</i>	Bronx	1,418,733	254,752	98,899	I-278 between I-87 & I-895	8,170,256
<i>ROCH</i>	Monroe	749,606	558,063	85,162	I-490 at I-590	15,963,343

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect 2013 data (NYS DMV, 2013)

³AADT reflects 2012 data (NYS DOT, 2012)

⁴County-level VMT reflects 2011 data (EPA, 2015a)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 21-2 include the following:

- Bronx County has the ninth highest county-level population among counties with NMP sites. The population of Rochester County is roughly half the Bronx County population and ranks 20th among NMP sites.
- County-level vehicle ownership for Bronx County ranks 32nd among counties with NMP sites, which is in the middle of the range among NMP sites. The county-level vehicle registration for Rochester County is more than twice the vehicle registration for Bronx County and ranks 19th compared to other NMP sites.
- Although the population for Bronx County is twice the population for Rochester County, the vehicle registration for Bronx County is roughly half the vehicle registration for Rochester County. The difference in county-level population and vehicle registration ranking for Bronx County may be explained by mass transportation systems.
- Traffic volume is higher near BXNY, which ranks 15th among NMP sites, than ROCH, which ranks 17th, although their rankings are similar. The traffic data for BXNY is for I-278 between I-87 and I-895; the traffic data for ROCH are provided for I-490 at I-590.

- County-level daily VMT for Monroe County is nearly twice the VMT for Bronx County. These VMT are in the middle of the range compared to other counties with NMP sites.

21.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in New York on sample days, as well as over the course of the year.

21.2.1 Climate Summary

Weather conditions are somewhat variable in New York City as frontal systems frequently affect the area. Precipitation is spread fairly evenly throughout the year, with thunderstorms in the summer and fall and more significant rain or snow events in the winter and spring. Wintertime monthly snow accumulations generally range from 3 inches to 10 inches. The proximity to the Atlantic Ocean offers a moderating influence from cold air outbreaks as well as the summertime heat. The urban heat island effect tends to keep the city warmer than outlying areas. Both influences result in a relatively small diurnal range of temperatures. In addition, air sinking down from the mountains to the west can help drive temperatures higher during warm spells. Northwesterly winds prevail during the winter months while southwesterly winds are common during the warmer months of the year (Wood, 2004; NCDC, 2015).

Rochester is located in western New York and borders Lake Ontario's south side. Elevation increases significantly from the shore to the southern-most parts of the city, rising over 800 feet. Lake Ontario acts as a moderating influence on the city's temperatures, both in the summer and the winter, as the lake does not freeze most winters. It also plays a major factor in the city's precipitation patterns. Lake effect snow enhances the area's snowfall totals, although snowfall rates tend to be higher near Lake Ontario and points east rather than farther inland. Ninety inches of snow can fall in the city during the average winter. Spring and summer tend to be sunny due to the stabilizing effect of the lake, while cloudy conditions are prevalent in the fall and winter. Prevailing winds are from the southwest year-round (Bair 1992; Wood, 2004).

21.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the New York monitoring sites (NCDC, 2013), as described in Section 3.4.2. The closest weather station to BXNY is located at La Guardia Airport, WBAN 14732. The closest weather station to ROCH is located at Greater Rochester International Airport, WBAN 14768. Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 21-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 21-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 21-3 is the 95 percent confidence interval for each parameter. Average meteorological conditions on sample days near BXNY and ROCH were representative of average weather conditions experienced throughout the year at each location. As expected, Table 21-3 shows that temperatures were cooler in western New York than in New York City. BXNY is among the windier locations with an NMP site, based on the 2013 average scalar wind speed.

Table 21-3. Average Meteorological Conditions near the New York Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
New York City, New York - BXNY									
La Guardia Airport 14732 (40.78, -73.88)	2.80 miles	Sample Days (61)	62.0 ± 4.8	55.5 ± 4.6	40.8 ± 4.8	48.6 ± 4.2	59.9 ± 3.3	1017.7 ± 1.7	9.3 ± 0.9
	156° (SSE)	2013	61.8 ± 1.9	55.6 ± 1.8	40.5 ± 1.9	48.5 ± 1.6	59.4 ± 1.4	1017.3 ± 0.7	9.1 ± 0.3
Rochester, New York - ROCH									
Greater Rochester Intl. Airport 14768 (43.12, -77.68)	6.84 miles	Sample Days (61)	57.0 ± 5.5	49.2 ± 4.9	39.2 ± 4.9	44.6 ± 4.6	70.8 ± 3.1	1017.5 ± 1.7	7.5 ± 0.9
	253° (WSW)	2013	57.2 ± 2.1	49.2 ± 1.9	39.1 ± 1.9	44.5 ± 1.8	70.6 ± 1.1	1017.2 ± 0.7	7.4 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

21.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations at La Guardia Airport (for BXNY) and Greater Rochester International Airport (for ROCH) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

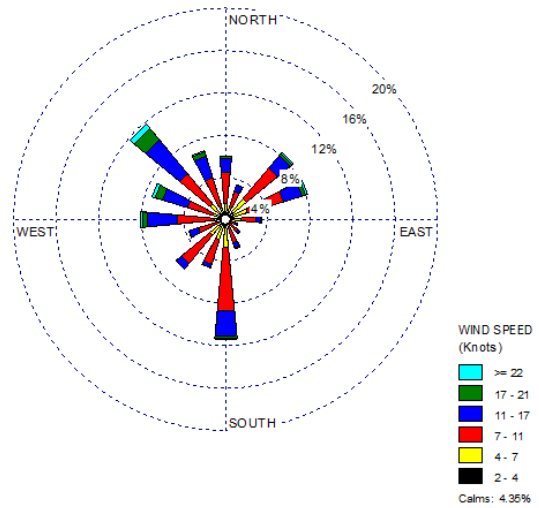
Figure 21-5 presents a map showing the distance between the weather station and BXNY, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 21-5 also presents three different wind roses for the BXNY monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 21-6 presents the distance map and wind roses for ROCH.

Figure 21-5. Wind Roses for the La Guardia Airport Weather Station near BXNY

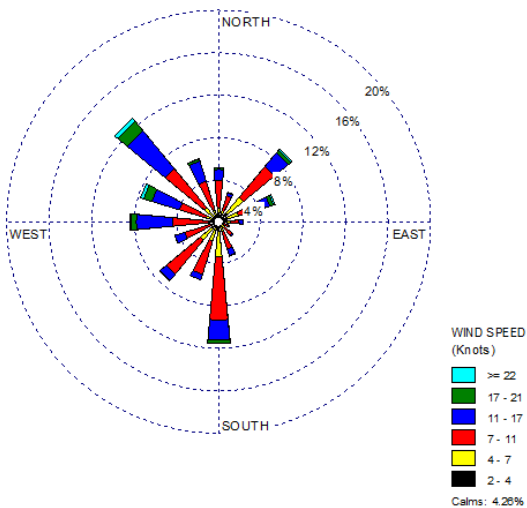
Location of BXNY and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

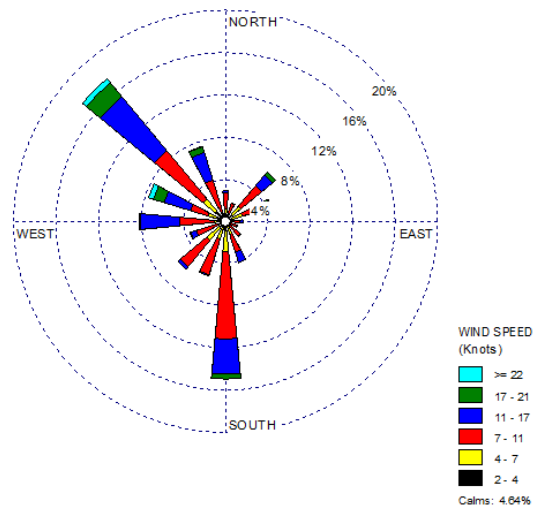
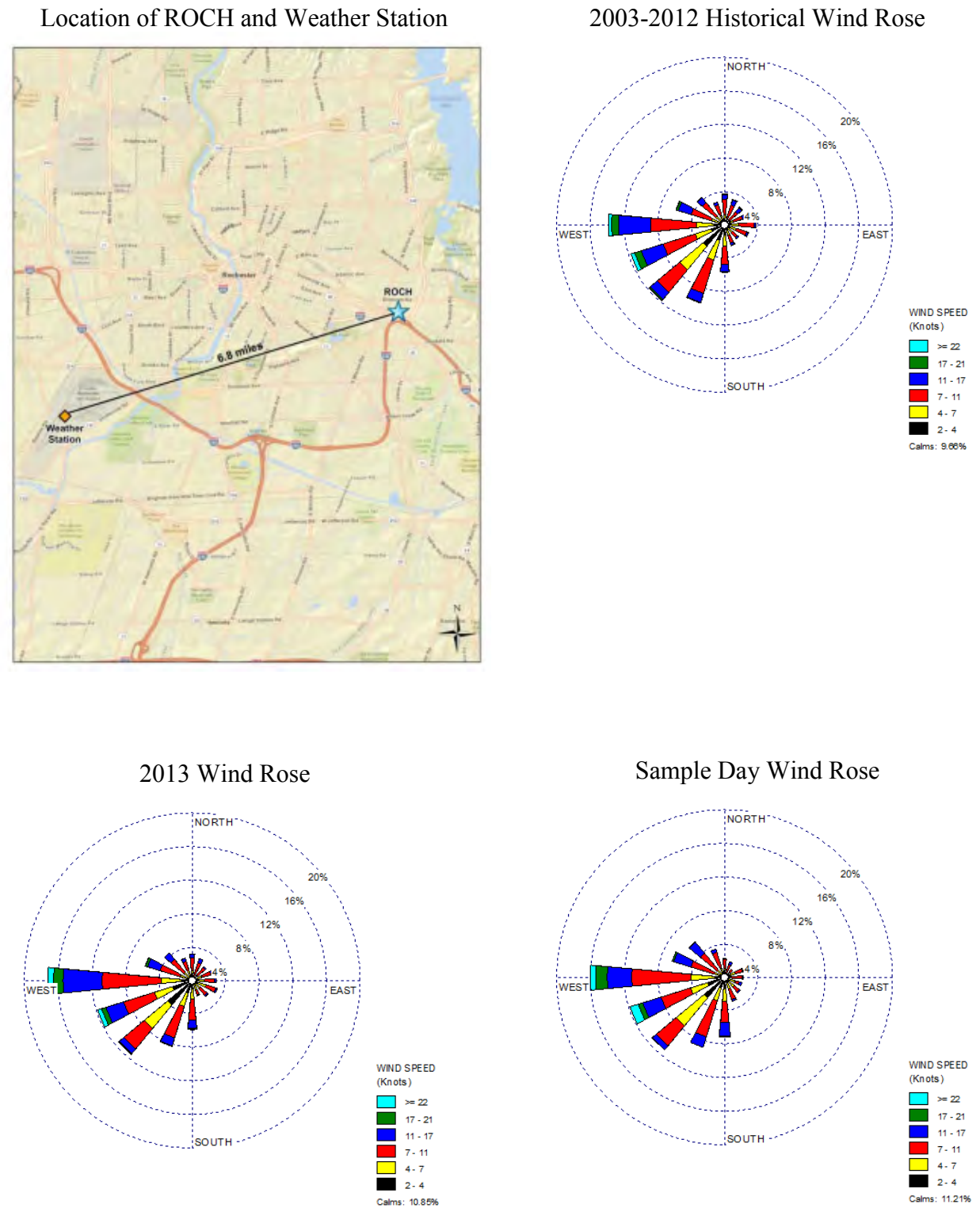


Figure 21-6. Wind Roses for the Greater Rochester International Airport Weather Station near ROCH



Observations from Figure 21-5 for BXNY include the following:

- The weather station at La Guardia Airport is located 2.8 miles southeast of BXNY. The East River and Rikers Island separate the site and the weather station.
- The historical wind rose shows that winds from a variety of directions are observed near BXNY, although winds from the southeast quadrant were rarely observed. Winds from the west to northwest to north account for nearly 40 percent of the wind observations. Winds from the northeast and east-northeast account for another 17 percent of observations while winds from the south account for nearly 12 percent. Calm winds (those less than or equal to 2 knots) were observed for less than 5 percent of the hourly measurements near BXNY.
- The full-year wind rose for 2013 shares many similarities with the historical wind rose, such as the prominence of winds from the northwest and the lack of winds from the southeast quadrant. There are some differences, though. For example, winds from the northeast account for a higher percentage than winds from the east-northeast, whereas the percentages are more similar historically.
- The sample day wind patterns resemble the wind patterns on the other wind roses in that northwesterly and southerly winds prevail, although these directions account for a higher percentage of winds on sample days (17 percent and 15 percent, respectively) compared to the historical and full-year wind roses. Fewer northerly, northeasterly, and east-northeasterly winds were observed on sample days.

Observations from Figure 21-6 for ROCH include the following:

- The Greater Rochester International Airport weather station is located 6.8 miles west-southwest of ROCH, with much of the southern half of the city of Rochester between them.
- The historical wind rose shows that winds from the south-southwest to west were frequently observed, accounting for nearly 50 percent of the wind observations. Winds from most other directions individually count for less than 4 percent of observations each. Calm winds were observed for less than 10 percent of the hourly measurements near ROCH, while the strongest winds were most frequently observed with west-southwesterly and westerly winds.
- The wind patterns shown on the 2013 wind rose are similar to the historical wind patterns for ROCH, although westerly winds account for an even higher percentage of wind observations in 2013 (nearly 17 percent).
- The sample day wind patterns are similar to those shown on the full-year and historical wind roses, although the percentage of calm winds is slightly higher.

21.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each New York monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 21-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 21-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Hexavalent chromium and PAHs were sampled for at both New York sites although hexavalent chromium sampling was discontinued in June 2013 at BXNY and July 2013 at ROCH.

Table 21-4. Risk-Based Screening Results for the New York Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
New York City, New York - BXNY						
Naphthalene	0.029	60	60	100.00	68.97	68.97
Fluorene	0.011	12	57	21.05	13.79	82.76
Acenaphthene	0.011	11	60	18.33	12.64	95.40
Fluoranthene	0.011	2	60	3.33	2.30	97.70
Benzo(a)pyrene	0.00057	1	58	1.72	1.15	98.85
Hexavalent Chromium	0.000083	1	19	5.26	1.15	100.00
Total		87	314	27.71		
Rochester, New York - ROCH						
Naphthalene	0.029	39	56	69.64	38.24	38.24
Acenaphthene	0.011	28	56	50.00	27.45	65.69
Fluorene	0.011	25	54	46.30	24.51	90.20
Fluoranthene	0.011	10	56	17.86	9.80	100.00
Total		102	222	45.95		

Observations from Table 21-4 include the following:

- Six pollutants failed screens for BXNY; 28 percent of concentrations for these six pollutants were greater than their associated risk screening value (or failed screens).

- Three pollutants, naphthalene, fluorene, and acenaphthene, were identified as pollutants of interest for BXNY.
- Four pollutants failed screens for ROCH; 46 percent of concentrations for these four pollutants were greater than their associated risk screening value (or failed screens).
- All four of these pollutants contributed to 95 percent of failed screens for ROCH; therefore, all four were identified as pollutants of interest for this site.
- For both sites, naphthalene, acenaphthene, and fluorene were identified as pollutants of interest. Naphthalene failed the majority of screens for each site, accounting for 69 percent of failed screens for BXNY and 38 percent of failed screens for ROCH.

21.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the New York monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at BXNY and ROCH are provided in Appendices M and O.

21.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each New York site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the

entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the New York monitoring sites are presented in Table 21-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 21-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the New York Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
New York City, New York - BXNY						
Acenaphthene	60/60	2.45 ± 0.55	8.05 ± 1.93	11.04 ± 1.85	4.19 ± 1.65	6.46 ± 1.15
Fluorene	57/60	3.34 ± 0.92	8.95 ± 2.22	11.02 ± 1.89	4.63 ± 1.51	7.01 ± 1.14
Naphthalene	60/60	108.15 ± 27.24	136.59 ± 28.35	137.49 ± 23.66	123.81 ± 25.23	126.77 ± 12.63
Rochester, New York - ROCH						
Acenaphthene	56/56	4.07 ± 3.43	40.71 ± 9.51	32.43 ± 10.54	6.56 ± 4.27	19.37 ± 5.35
Fluoranthene	56/56	1.37 ± 0.36	8.42 ± 2.92	10.30 ± 2.72	2.27 ± 0.82	5.18 ± 1.33
Fluorene	54/56	2.73 ± 1.48	27.22 ± 6.82	23.21 ± 7.36	4.82 ± 2.80	13.40 ± 3.65
Naphthalene	56/56	36.71 ± 8.41	101.06 ± 28.92	85.51 ± 18.63	37.03 ± 10.89	62.20 ± 11.15

Observations for BXNY from Table 21-5 include the following:

- Acenaphthene and naphthalene were detected in all of the valid PAH samples collected at BXNY, while three non-detects of fluorene were measured.
- Of the pollutants of interest for BXNY, naphthalene has the highest annual average concentration, while the annual averages for acenaphthene and fluorene are similar to each other. Concentrations of naphthalene measured at BXNY range from 39.7 ng/m³ to 231 ng/m³. Concentrations of acenaphthene range from 1.11 ng/m³ to 19.1 ng/m³ while concentrations of fluorene range from 1.94 ng/m³ to 18.7 ng/m³ plus three non-detects.
- Concentrations of acenaphthene and fluorene are significantly higher during the warmer months than the cooler months, based on the quarterly average concentrations. Concentrations measured during the second and third quarters of 2013 also exhibit more variability, based on the confidence intervals shown. A similar

observation can be made for naphthalene although the confidence intervals indicate the differences are not statistically significant.

Observations for ROCH from Table 21-5 include the following:

- Acenaphthene, fluoranthene, and naphthalene were detected in all of the valid PAH samples collected at ROCH, while two non-detects of fluorene were measured.
- Of the pollutants of interest for ROCH, naphthalene has the highest annual average concentration, followed by acenaphthene, fluorene, and then fluoranthene.
- Concentrations of naphthalene measured at ROCH range from 13.4 ng/m³ to 216 ng/m³. Concentrations of acenaphthene range from 0.383 ng/m³ to 69.7 ng/m³; concentrations of fluoranthene range from 0.483 ng/m³ to 19.1 ng/m³; and concentrations of fluorene range from 0.631 ng/m³ to 53.4 ng/m³ plus two non-detects.
- Quarterly average concentrations of each of the pollutants of interest for ROCH were considerably higher during the second and third quarters of the year. For example, all nine acenaphthene concentrations less than 1 ng/m³ were measured during the first or fourth quarters of 2013 while all but two of the 20 concentrations greater than 25 ng/m³ were measured during the second and third quarters of 2013.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for BXNY and ROCH from those tables include the following:

- ROCH and BXNY have the second and fifth highest annual average concentrations of acenaphthene among NMP sites sampling PAHs, as shown in Table 4-11.
- The annual average concentration of naphthalene for BXNY ranks third compared to other NMP sites sampling PAHs while the annual average concentration for ROCH does not appear in Table 4-11 for naphthalene (it ranks 14th).

21.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created each of the pollutants of interest for BXNY and ROCH. Figures 21-7 through 21-10 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations for each pollutant, as described in Section 3.4.3.1.

Figure 21-7. Program vs. Site-Specific Average Acenaphthene Concentrations

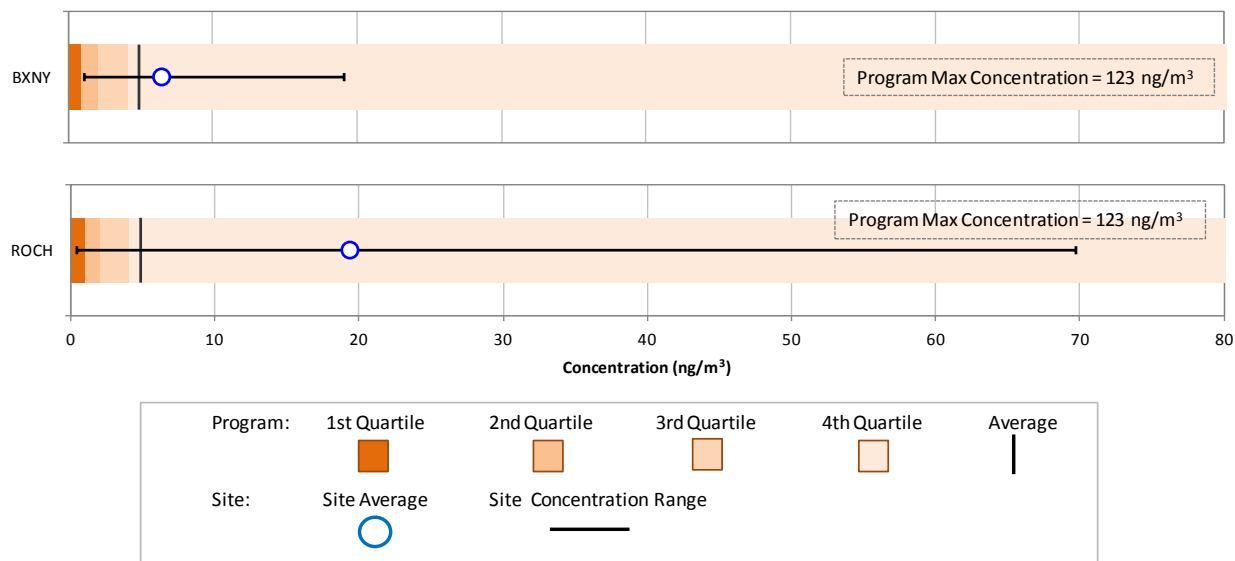


Figure 21-8. Program vs. Site-Specific Average Fluoranthene Concentration

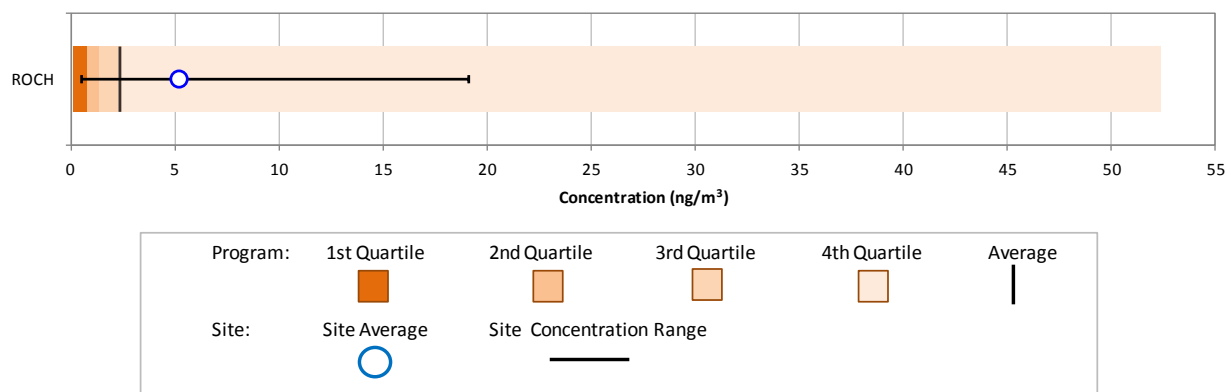


Figure 21-9. Program vs. Site-Specific Average Fluorene Concentrations

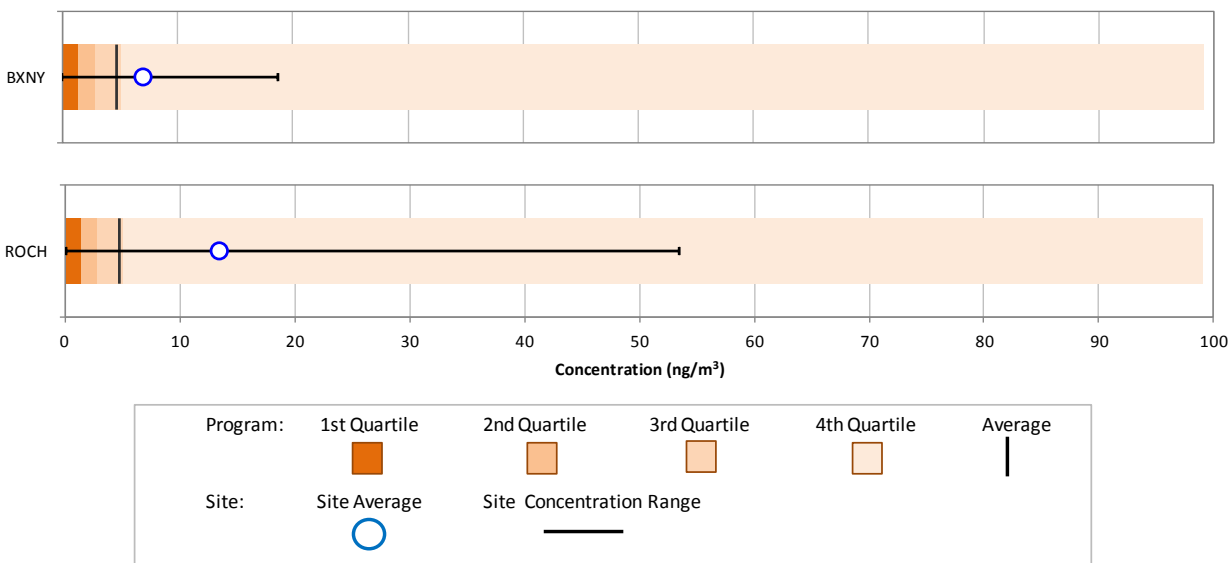
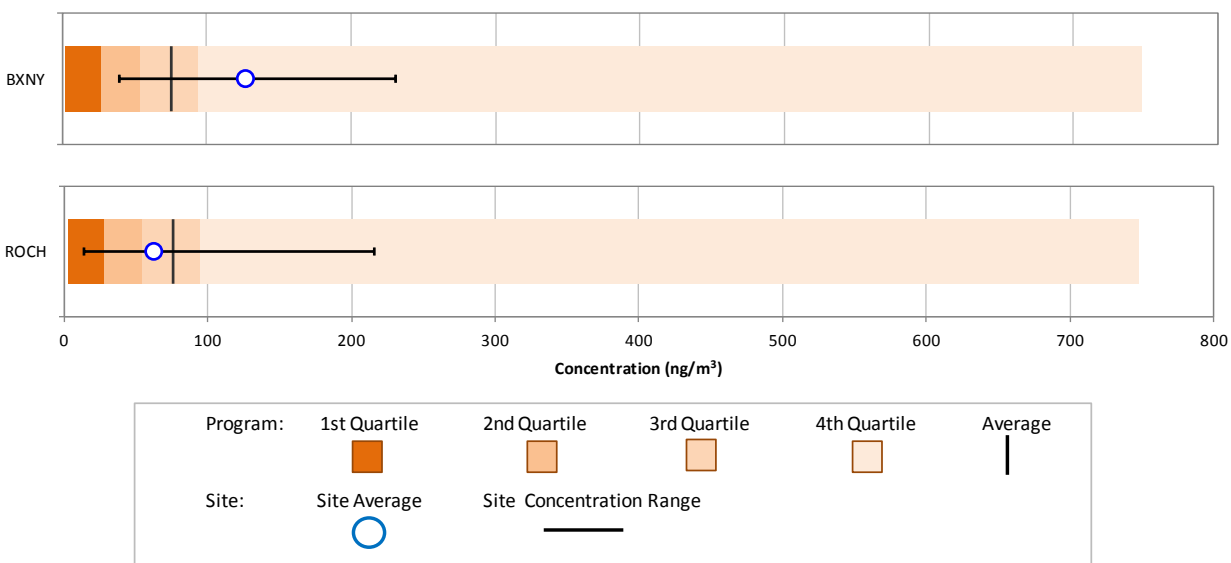


Figure 21-10. Program vs. Site-Specific Average Naphthalene Concentrations



Observations from Figures 21-7 through 21-10 include the following:

- Figure 21-7 presents the box plots for acenaphthene for both sites. Note that the program-level maximum concentration (123 ng/m³) is not shown directly on the box plots because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 80 ng/m³. The box plots show that although the maximum acenaphthene concentration measured across the program was not measured at either New York site, the maximum concentration measured at ROCH is among the higher concentrations. The entire range of acenaphthene concentrations measured at BXNY is less than the annual average concentration for ROCH. The annual average concentrations for both sites are greater than the program-level

average concentration, although the annual average for ROCH is three times greater the annual average concentration for BXNY. Recall that ROCH has the second highest annual average concentration of acenaphthene among NMP sites sampling PAHs (behind NBIL).

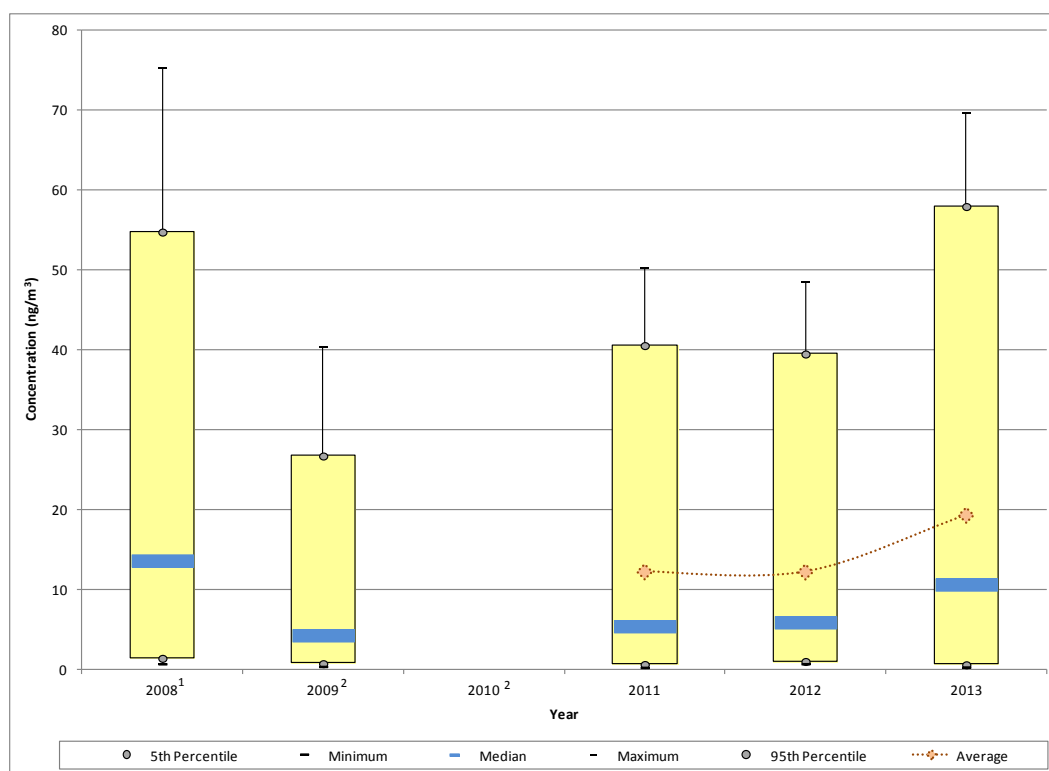
- Figure 21-8 presents the box plot for fluoranthene for ROCH, the only New York site for which this is a pollutant of interest. Although the maximum concentration of fluoranthene measured at ROCH is less than the maximum concentration measured across the program, it is the seventh highest concentration measured among NMP sites sampling PAHs. The annual average concentration for ROCH is more than three times greater the program-level average concentration. This site is one of only three NMP sites sampling PAHs with fluoranthene as a pollutant of interest.
- Figure 21-9 presents the box plots for fluorene for both New York sites. The maximum concentration of fluorene measured at ROCH is considerably greater than the maximum concentration measured at BXNY but is roughly half the maximum concentration measured across the program (although the maximum concentration measured at ROCH is among the higher measurements). The annual average concentrations for both sites are greater than the program-level average, although the annual average for BXNY is roughly half the annual average concentration for ROCH.
- Figure 21-10 presents the box plots for naphthalene for both sites. In contrast to the box plots for the other pollutants of interest in common for the New York sites, Figure 21-10 shows that the naphthalene concentrations measured at ROCH are less than the ones measured at BXNY. The annual average naphthalene concentration for ROCH is half the annual average for BXNY and is less than the program-level average concentration. The annual average concentration for BXNY is greater than the program-level average and third quartile. Recall that BXNY has the third highest annual average concentration of naphthalene among NMP sites sampling PAHs, even though the range of measurements is not that large. The minimum naphthalene concentration measured at BXNY is greater than the program-level first quartile. The minimum naphthalene concentration measured at BXNY is the highest minimum concentration of this pollutant measured at an NMP site.

21.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. In June 2010, the monitoring instruments at BXNY were relocated to a new, temporary location due to roofing construction near the BXNY site. Two years later, the instrumentation was returned to the BXNY site and sampling resumed at this location in July 2012. A trends analysis was not performed for BXNY because sampling did not occur consecutively at the same location.

Sampling for PAHs at ROCH began in July 2008, so a trends analysis was performed for ROCH. However, due to the mid-year start, a 1-year average concentration for 2008 is not presented, although the range of measurements is provided. In addition, a collection error was discovered at the site, resulting in the invalidation of nearly one and one-half years' worth of samples between July 2009 and December 2010. Thus, the range of measurements is provided for 2009, although a 1-year average concentration is not provided and no statistical metrics are provided for 2010. This, combined with the mid-year start in 2008, results in the calculation of few 1-year average concentrations for the ROCH monitoring site.

Figure 21-11. Yearly Statistical Metrics for Acenaphthene Concentrations Measured at ROCH



¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2008.

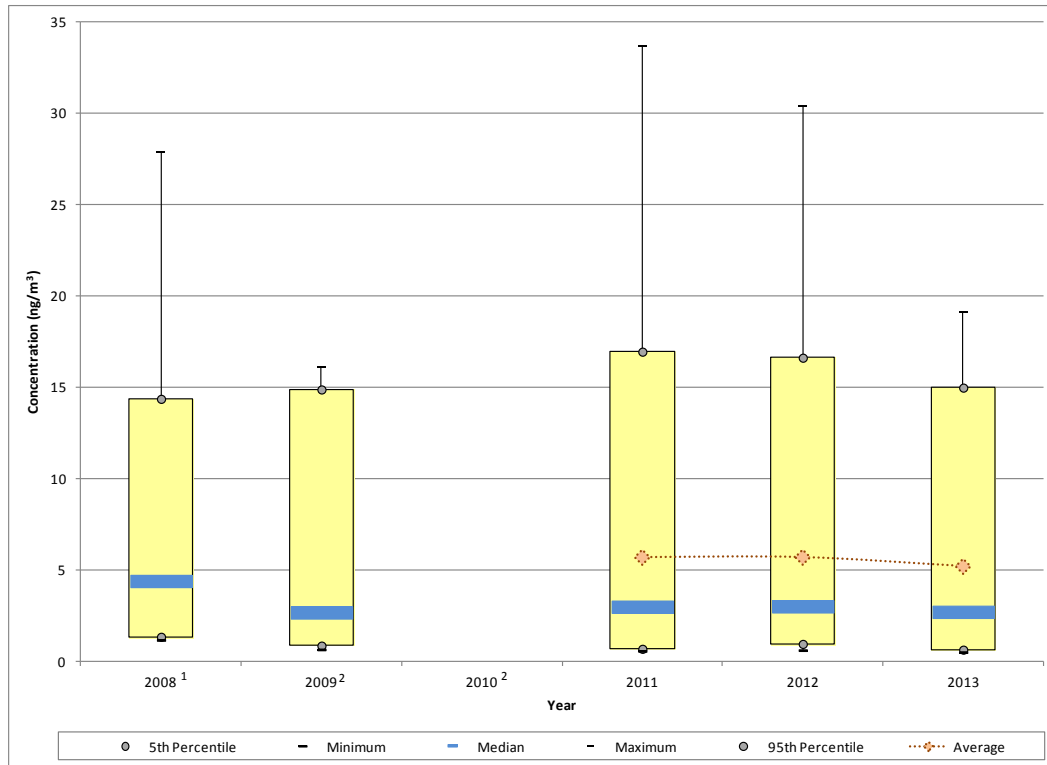
² Some statistical metrics are not presented because data from July 2009 to Dec 2010 was invalidated.

Observations from Figure 21-11 for acenaphthene measurements collected at ROCH include the following:

- The range of acenaphthene concentrations appears to have decreased by half from 2008 to 2009, although 2008 includes data from July through December while 2009 includes data from January through June.
- The measurements collected in 2011 are similar to the measurements collected in 2012.

- The range of concentrations increased considerably from 2012 to 2013. The median concentration nearly doubled from 2012 to 2013 while the 1-year average concentration increased by 58 percent.

Figure 21-12. Yearly Statistical Metrics for Fluoranthene Concentrations Measured at ROCH



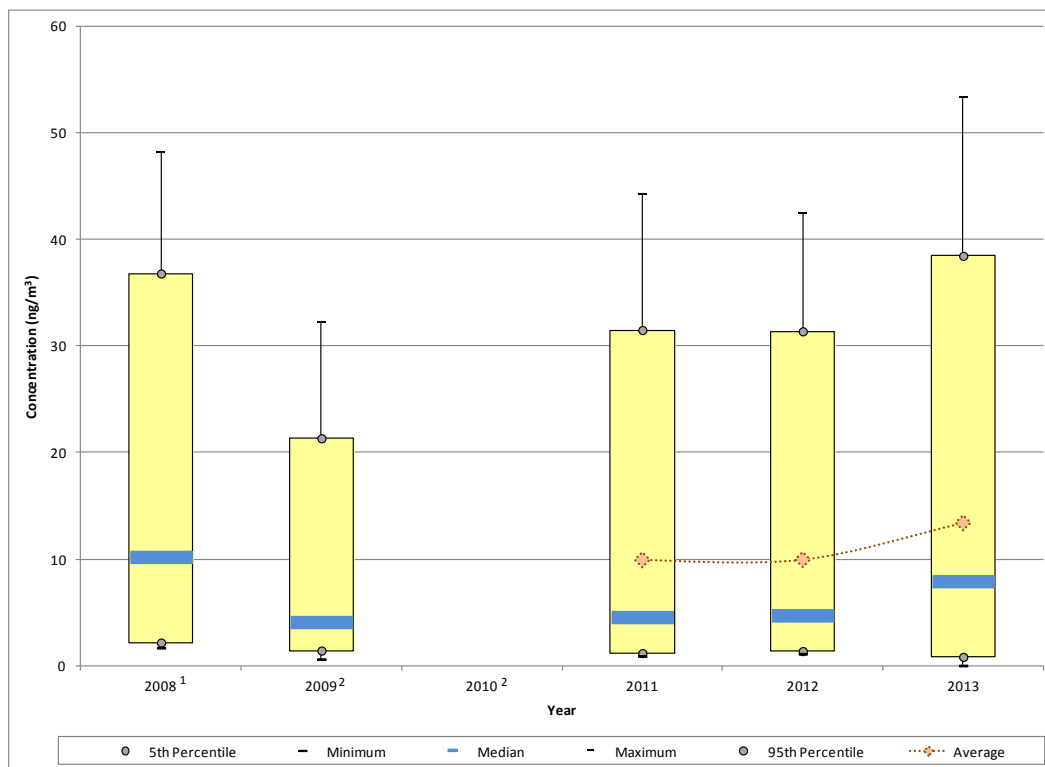
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2008.

² Some statistical metrics are not presented because data from July 2009 to Dec 2010 was invalidated.

Observations from Figure 21-12 for fluoranthene measurements collected at ROCH include the following:

- With the exception of the 95th percentile, each of the statistical parameters exhibits a decrease from 2008 to 2009, although 2008 includes data from July through December while 2009 includes data from January through June.
- The median concentration decreased considerably from 2008 to 2009, after which little change is shown. Between 2009 and 2013, the median concentration varied by less than 0.35 ng/m³, ranging from 2.66 ng/m³ (2009) to 2.99 ng/m³ (2012). Similarly, the 1-year average concentrations have changed little, with 0.50 ng/m³ separating them, even though the range of concentrations measured at ROCH has decreased each year since 2011.

Figure 21-13. Yearly Statistical Metrics for Fluorene Concentrations Measured at ROCH



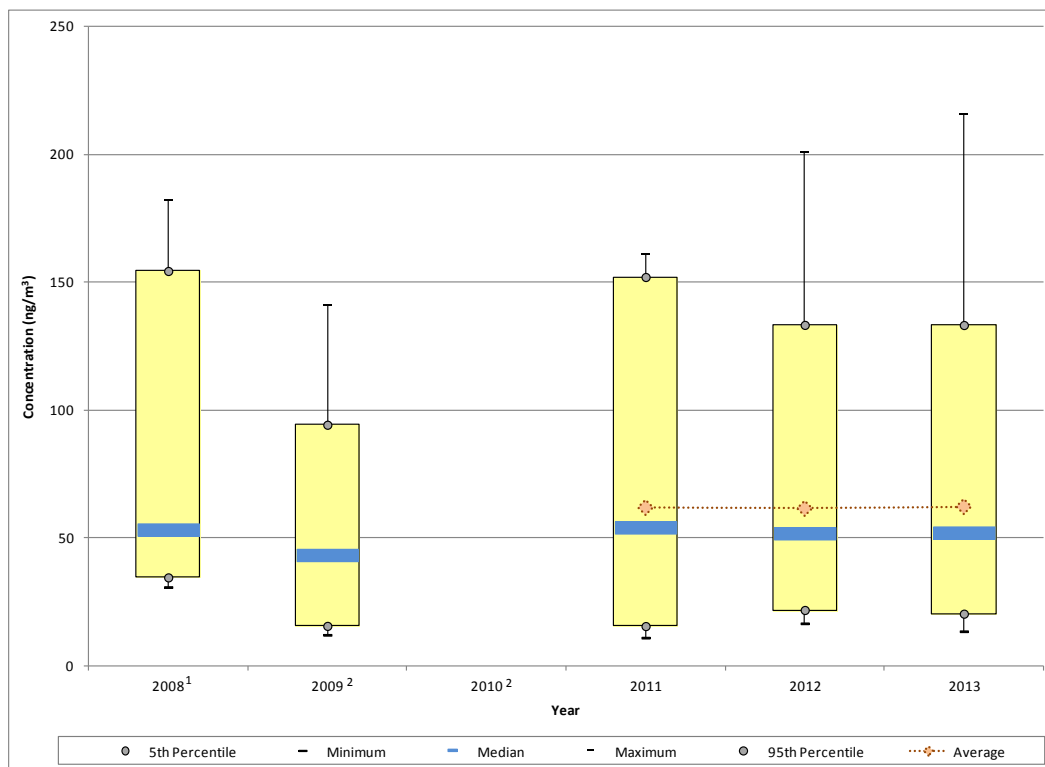
¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2008.

² Some statistical metrics are not presented because data from July 2009 to Dec 2010 was invalidated.

Observations from Figure 21-13 for fluorene measurements collected at ROCH include the following:

- The trends graph for fluorene resembles the trends graph for acenaphthene.
- The range of fluorene concentrations appears to have decreased from 2008 to 2009 and the median concentration decreased by more than half during this time frame, although 2008 includes data from July through December while 2009 includes data from January through June.
- The measurements collected in 2011 are similar to the measurements collected in 2012.
- The range of concentrations increased from 2012 to 2013, when the maximum fluorene concentration (53.4 ng/m³) since the onset of sampling at ROCH was measured. The median increased by 67 percent from 2012 to 2013 while the 1-year average concentration increased by about half that percentage.

Figure 20-14. Yearly Statistical Metrics for Naphthalene Concentrations Measured at ROCH



¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2008.

² Some statistical metrics are not presented because data from July 2009 to Dec 2010 was invalidated.

Observations from Figure 20-14 for naphthalene measurements collected at ROCH include the following:

- Similar to the other pollutants of interest, the range of naphthalene concentrations appears to have decreased from 2008 to 2009.
- Even though the maximum concentration has increased each year since 2011, the 1-year average naphthalene concentrations calculated for 2011, 2012, and 2013 exhibit little change, varying by less than 1 ng/m³ across the time period.

21.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the New York monitoring sites. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

21.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the New York sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 21-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 21-6. Risk Approximations for the New York Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
New York City, New York - BXNY						
Acenaphthene	0.000088	--	60/60	6.46 ± 1.15	0.57	--
Fluorene	0.000088	--	57/60	7.01 ± 1.14	0.62	--
Naphthalene	0.000034	0.003	60/60	126.77 ± 12.63	4.31	0.04
Rochester, New York - ROCH						
Acenaphthene	0.000088	--	56/56	19.37 ± 5.35	1.70	--
Fluoranthene	0.000088	--	56/56	5.18 ± 1.33	0.46	--
Fluorene	0.000088	--	54/56	13.40 ± 3.65	1.18	--
Naphthalene	0.000034	0.003	56/56	62.20 ± 11.15	2.11	0.02

-- = A Cancer URE or Noncancer RfC is not available.

Observations for the New York sites from Table 21-6 include the following:

- Naphthalene has the highest annual average concentration among the pollutants of interest for each site, although the annual average concentration for BXNY is significantly higher than the annual average for ROCH.

- Naphthalene also has the highest cancer risk approximation for each site (4.31 in-a-million for BXNY and 2.11 in-a-million for ROCH). The cancer risk approximations for the other pollutants of interest for each site are all less than 2 in-a-million.
- Only naphthalene has a noncancer RfC. The noncancer hazard approximations for naphthalene for each site are both less than 0.05, considerably less than 1.0, indicating that no adverse noncancer health effects are expected from this individual pollutant.

21.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 21-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 21-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 21-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 21-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 21-7. Table 21-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 21.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 21-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the New York Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
New York City, New York (Bronx County) - BXNY					
Benzene	127.66	Formaldehyde	1.04E-03	Naphthalene	4.31
Ethylbenzene	92.28	Benzene	9.96E-04	Fluorene	0.62
Tetrachloroethylene	81.66	1,3-Butadiene	4.42E-04	Acenaphthene	0.57
Formaldehyde	80.26	Naphthalene	2.76E-04		
Acetaldehyde	47.43	Ethylbenzene	2.31E-04		
1,3-Butadiene	14.74	Arsenic, PM	2.19E-04		
Naphthalene	8.11	POM, Group 2b	1.53E-04		
POM, Group 2b	1.74	Nickel, PM	1.40E-04		
POM, Group 2d	1.53	POM, Group 2d	1.35E-04		
Trichloroethylene	1.05	POM, Group 5a	1.11E-04		
Rochester, New York (Monroe County) - ROCH					
Benzene	257.25	Formaldehyde	2.24E-03	Naphthalene	2.11
Formaldehyde	172.39	Benzene	2.01E-03	Acenaphthene	1.70
Ethylbenzene	140.93	1,3-Butadiene	1.24E-03	Fluorene	1.18
Acetaldehyde	98.59	Naphthalene	6.88E-04	Fluoranthene	0.46
Dichloromethane	46.10	POM, Group 2b	5.08E-04		
1,3-Butadiene	41.31	Arsenic, PM	3.81E-04		
Tetrachloroethylene	24.16	Ethylbenzene	3.52E-04		
Naphthalene	20.23	POM, Group 2d	3.16E-04		
Trichloroethylene	6.40	Hexavalent Chromium	2.69E-04		
POM, Group 2b	5.77	POM, Group 5a	2.69E-04		

Table 21-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the New York Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
New York City, New York (Bronx County) - BXNY					
Toluene	2,161.13	Acrolein	203,787.77	Naphthalene	0.04
Methanol	793.11	Formaldehyde	8,190.17		
Hexane	479.04	1,3-Butadiene	7,368.79		
Xylenes	293.26	Acetaldehyde	5,270.29		
Ethylene glycol	275.15	Benzene	4,255.29		
Benzene	127.66	Cadmium, PM	3,946.26		
Ethylbenzene	92.28	Arsenic, PM	3,399.31		
Tetrachloroethylene	81.66	Nickel, PM	3,238.72		
Formaldehyde	80.26	Xylenes	2,932.64		
Methyl isobutyl ketone	63.81	Naphthalene	2,702.28		
Rochester, New York (Monroe County) - ROCH					
Toluene	1,679.94	Acrolein	492,322.38	Naphthalene	0.02
Methanol	510.18	1,3-Butadiene	20,653.74		
Xylenes	507.26	Formaldehyde	17,591.01		
Hexane	498.21	Acetaldehyde	10,954.81		
Benzene	257.25	Hydrochloric acid	10,479.37		
Hydrochloric acid	209.59	Cadmium, PM	9,067.59		
Formaldehyde	172.39	Benzene	8,575.15		
Ethylene glycol	149.53	Naphthalene	6,742.12		
Ethylbenzene	140.93	Arsenic, PM	5,913.63		
Acetaldehyde	98.59	Nickel, PM	5,849.56		

Observations from Table 21-7 include the following:

- Benzene, ethylbenzene, and tetrachloroethylene are the highest emitted pollutants with cancer UREs in Bronx County while benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants in Monroe County.
- Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for both New York counties.
- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Bronx County; six of the highest emitted pollutants also have the highest toxicity-weighted emissions for Monroe County.
- Naphthalene, which is a pollutant of interest for both sites and has the highest cancer risk approximation for each site, appears on both emissions-based lists for Bronx and Monroe Counties.
- Emissions of several POM Groups rank among the highest emitted pollutants as well as the pollutants with the highest toxicity-weighted emissions for Bronx County. POM, Group 2b appears on both emissions-based lists for Bronx County and includes several PAHs sampled for at BXNY, including acenaphthene, fluoranthene, and fluorene. POM, Group 2d also appears on both emissions-based lists for Bronx County and includes anthracene, phenanthrene, and pyrene. None of these pollutants failed screens for BXNY. POM, Group 5a also appears among those with the highest toxicity-weighted emissions for Bronx County and includes benzo(a)pyrene, which failed a single screen for BXNY.
- POM, Groups 2b, 2d, and 5a also appear among the pollutants with the highest toxicity-weighted emissions for Monroe County while only POM, Group 2b appears among the highest emitted pollutants for Monroe County.

Observations from Table 21-8 include the following:

- Toluene and methanol are the highest emitted pollutants with noncancer RfCs in both Bronx and Monroe Counties. The emissions of toluene are considerably higher than the other pollutants listed for both Bronx and Monroe Counties.
- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) is acrolein for both counties. Formaldehyde and 1,3-butadiene round out the top three for both counties, although the order varies.
- Three of the highest emitted pollutants in Bronx County are also among the pollutants with the highest toxicity-weighted emissions; four of the highest emitted pollutants in Monroe County are also among the pollutants with the highest toxicity-weighted emissions.

- Naphthalene is the only pollutant of interest for each site for which a noncancer hazard approximation could be calculated. Naphthalene is among the pollutants with the highest toxicity-weighted emissions for each county, but is not among the highest emitted pollutants with a noncancer toxicity factor for either county.

21.6 Summary of the 2013 Monitoring Data for BXNY and ROCH

Results from several of the data treatments described in this section include the following:

- ❖ *Six pollutants failed screens for BXNY, of which three were identified as pollutants of interest. Four pollutants failed screens for ROCH, all of which were identified as pollutants of interest. Naphthalene, acenaphthene, and fluorene were identified as pollutants of interest for both New York monitoring sites.*
- ❖ *Naphthalene had the highest annual average concentration for both sites, although the annual average for BXNY is twice the annual average for ROCH.*
- ❖ *Concentrations of acenaphthene and fluorene for both sites and fluoranthene for ROCH were highest during the warmer months of the year.*
- ❖ *ROCH and BXNY have the second and fifth highest annual average concentrations of acenaphthene (respectively) among NMP sites sampling PAHs. BXNY has the third highest annual average concentration of naphthalene among NMP sites sampling PAHs.*
- ❖ *Naphthalene has the highest cancer risk approximation among the pollutants of interest for both BXNY and ROCH. None of the pollutants of interest have noncancer hazard approximations greater than an HQ of 1.0.*

22.0 Sites in Oklahoma

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP sites in Oklahoma, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

22.1 Site Characterization

This section characterizes the Oklahoma monitoring sites by providing geographical and physical information about the locations of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

Three Oklahoma sites (TOOK, TMOK, and TROK) are located in Tulsa, Oklahoma. Two sites are located in Oklahoma City, Oklahoma (ADOK and OCOK), although the instrumentation at ADOK was moved mid-year to a new location in Yukon, Oklahoma, just west of Oklahoma City (YUOK).

Figures 22-1 through 22-3 are composite satellite images retrieved from ArcGIS Explorer showing the Tulsa monitoring sites and their immediate surroundings. Figure 22-4 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 22-4. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Figures 22-5 through 22-8 are the composite satellite maps and emissions source map for the Oklahoma City sites. Table 22-1 provides supplemental geographical information such as land use, location setting, and locational coordinates for each site.

Figure 22-1. Public Works, Tulsa, Oklahoma (TOOK) Monitoring Site

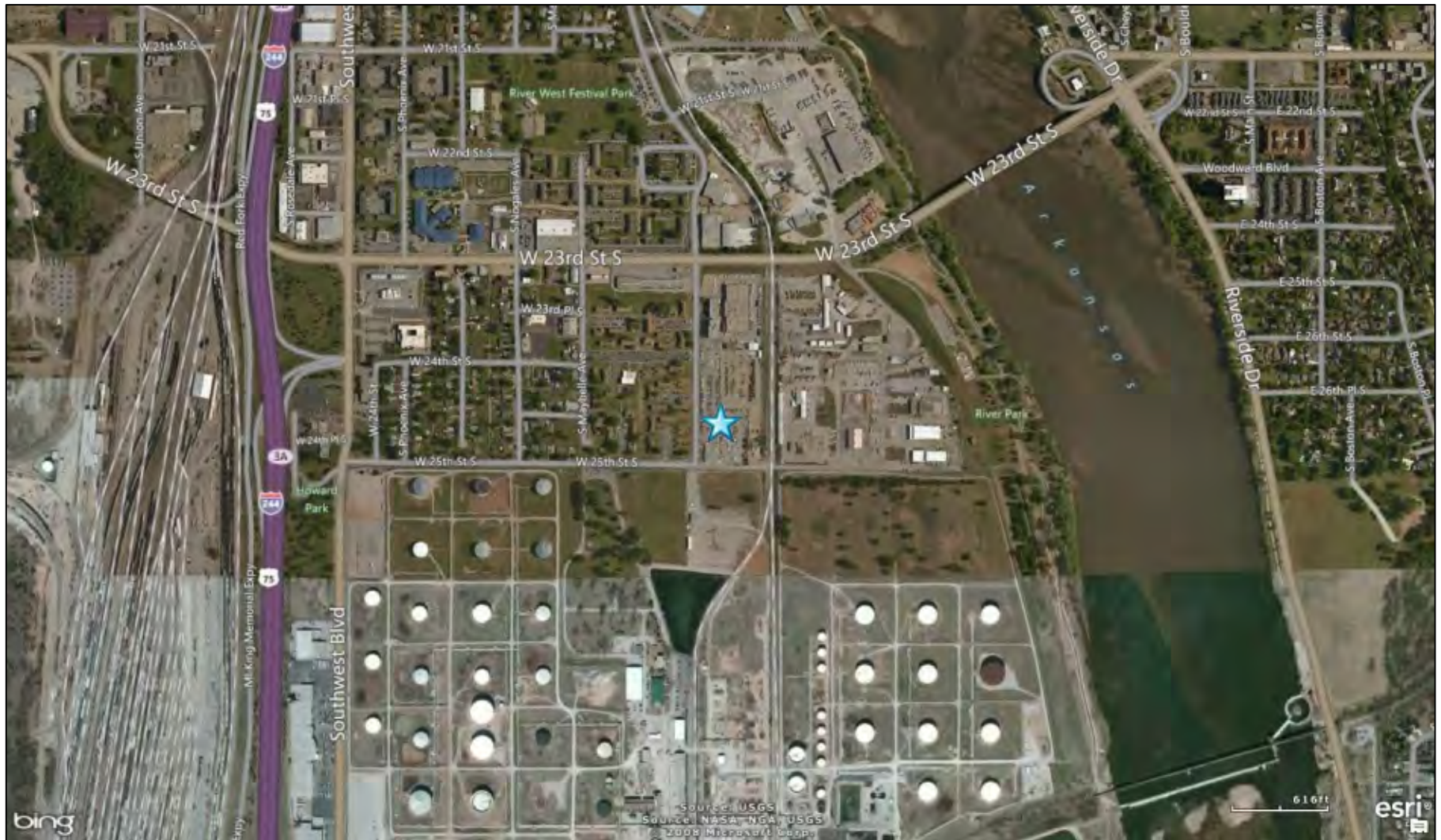
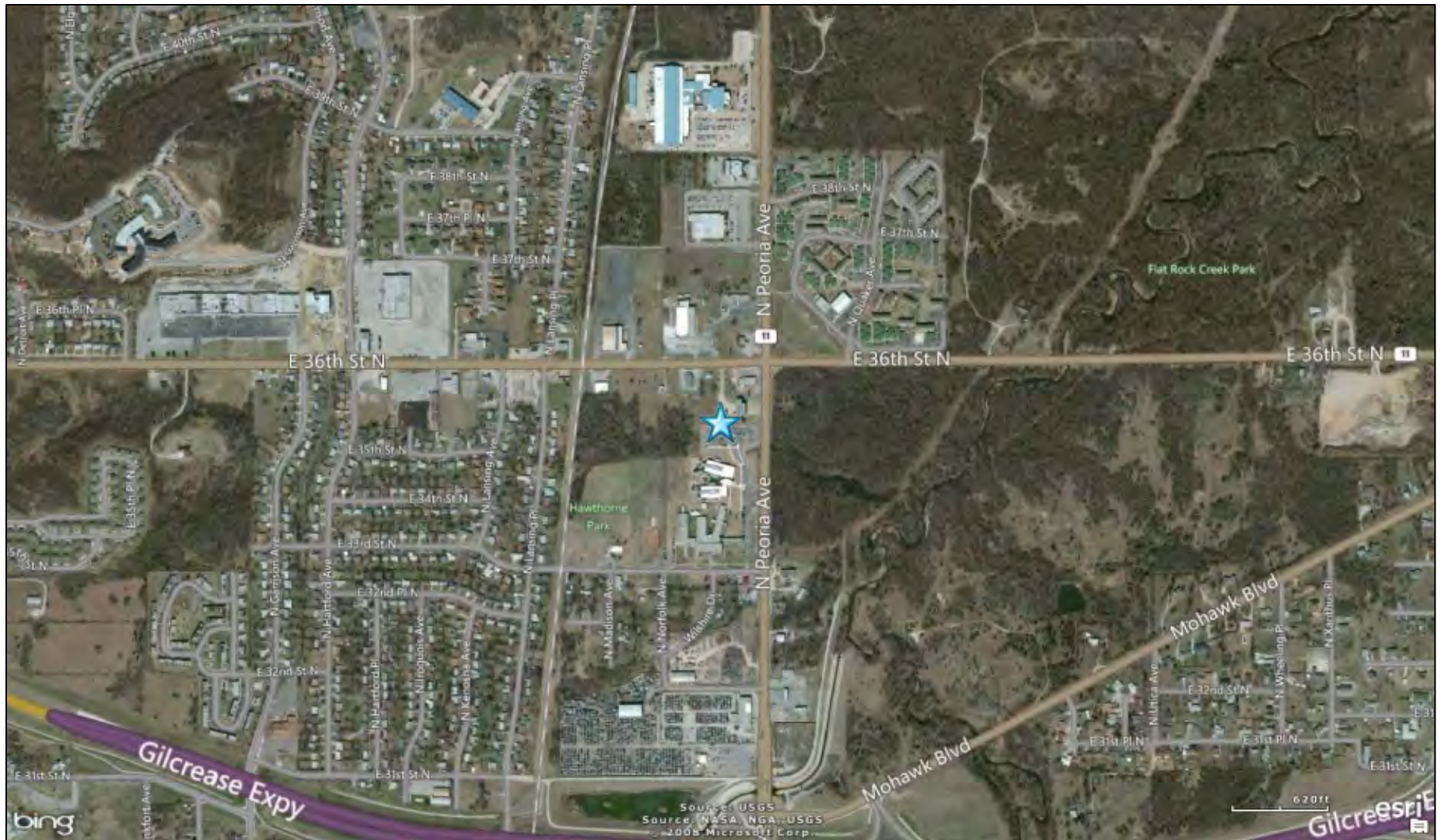


Figure 22-2. Fire Station, Tulsa, Oklahoma (TMOK) Monitoring Site



22-4



Figure 22-4. NEI Point Sources Located Within 10 Miles of TMOK, TOOK, and TROK

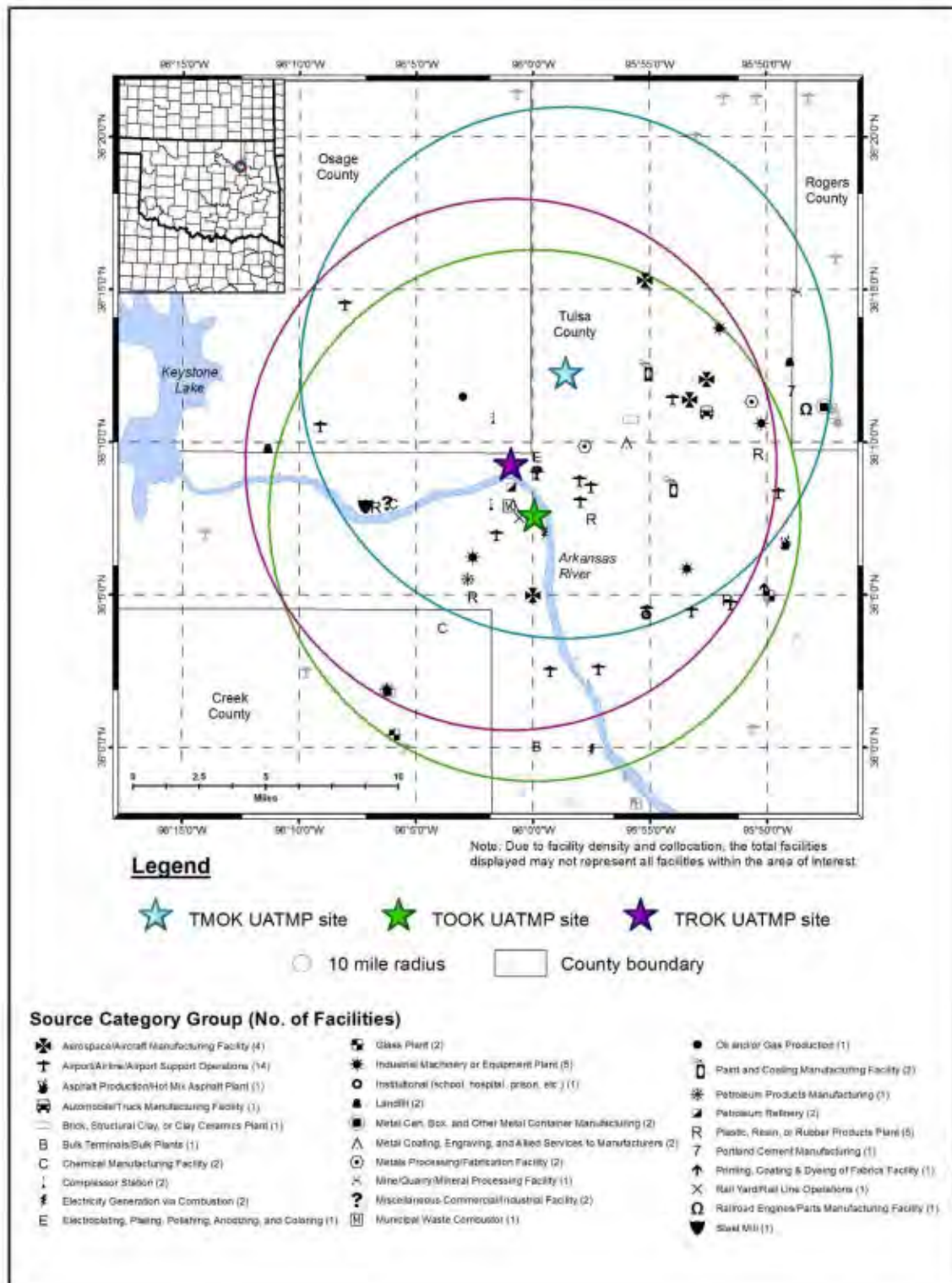


Figure 22-5. Air Depot, Oklahoma City, Oklahoma (ADOK) Monitoring Site



Figure 22-6. Oklahoma City, Oklahoma (OCOK) Monitoring Site

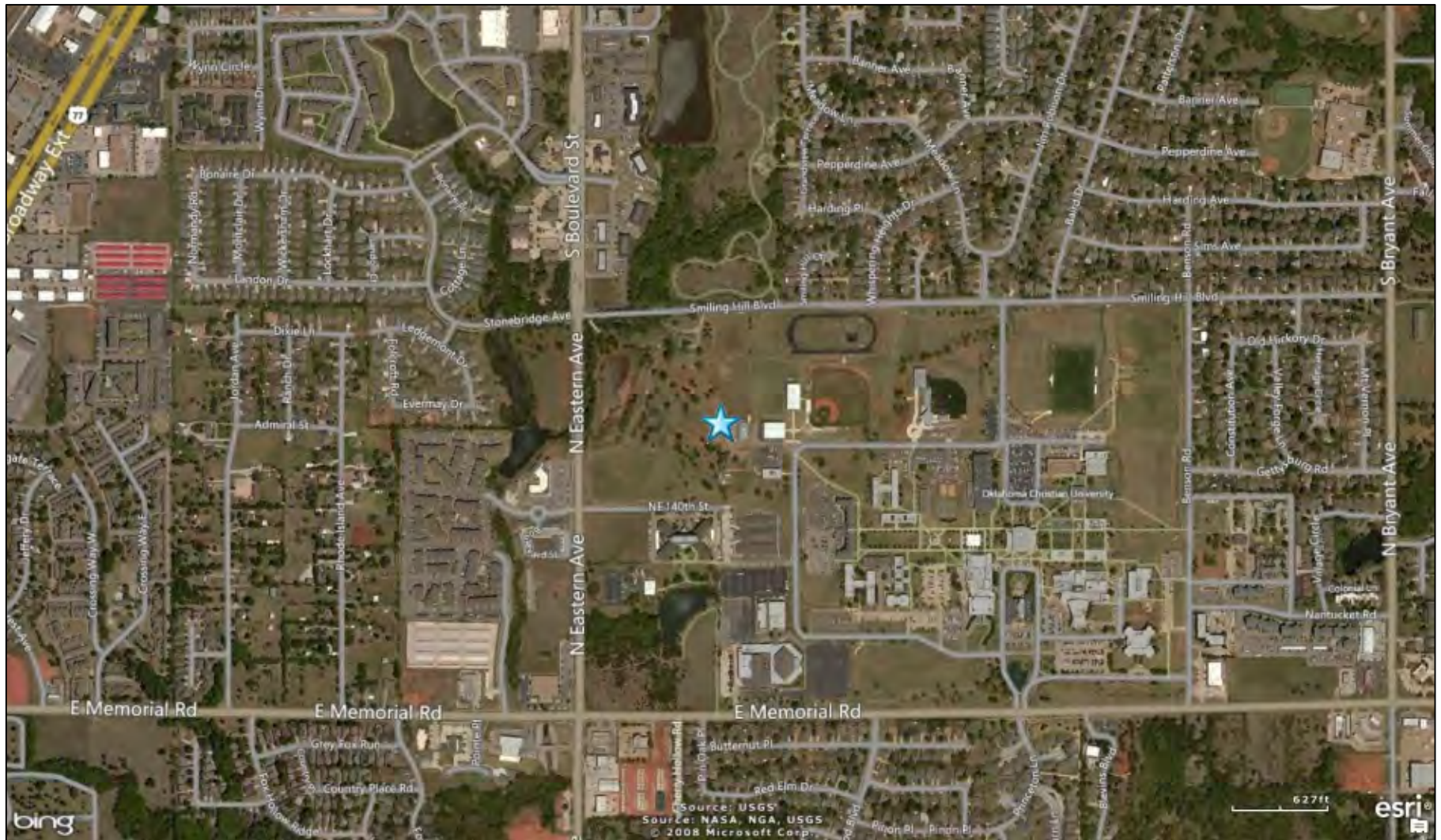


Figure 22-7. Yukon, Oklahoma (YUOK) Monitoring Site



Figure 22-8. NEI Point Sources Located Within 10 Miles of ADOK, OCOK, and YUOK

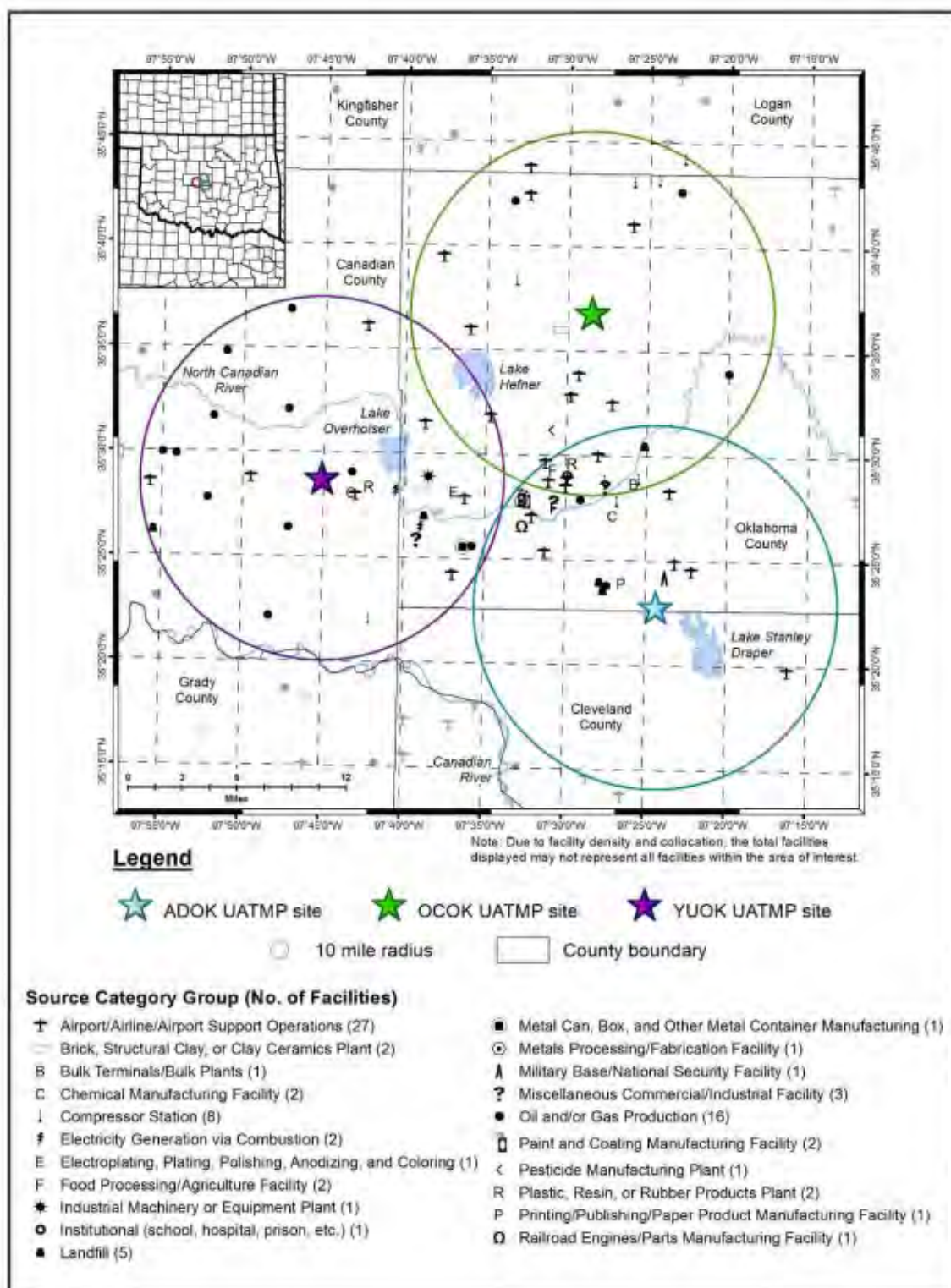


Table 22-1. Geographical Information for the Oklahoma Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
TOOK	40-143-0235	Tulsa	Tulsa	Tulsa, OK	36.126945, -95.998941	Industrial	Urban/City Center	SO ₂ , H ₂ S, Meteorological parameters.
TMOK	40-143-1127	Tulsa	Tulsa	Tulsa, OK	36.204902, -95.976537	Residential	Urban/City Center	CO, SO ₂ , NO _y , NO, NO ₂ , NO _x , O ₃ , Meteorological parameters, PM ₁₀ , PM Coarse, PM _{2.5} , and PM _{2.5} Speciation, IMPROVE Speciation.
TROK	40-143-0179	Tulsa	Tulsa	Tulsa, OK	36.154830, -96.015845	Industrial	Urban/City Center	SO ₂ , H ₂ S, Meteorological parameters.
ADOK	40-109-0042	Oklahoma City	Oklahoma	Oklahoma City, OK	35.380316, -97.405720	Commercial	Urban/City Center	None.
OCOK	40-109-1037	Oklahoma City	Oklahoma	Oklahoma City, OK	35.614131, -97.475083	Residential	Suburban	CO, SO ₂ , NO, NO ₂ , NO _x , O ₃ , Meteorological parameters, PM coarse, PM ₁₀ , PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
YUOK	40-017-0101	Yukon	Canadian	Oklahoma City, OK	35.479215, -97.751503	Commercial	Suburban	Meteorological parameters, NO, NO ₂ , NO _x , O ₃ .

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

TOOK is located in West Tulsa, on the southwest side of the Arkansas River. The site is located in the parking lot of the Public Works building. The monitoring site is positioned between the Arkansas River and I-244, which runs parallel to Southwest Boulevard. The surrounding area is primarily industrial, although residential areas are located immediately west of the site. The site is located near the City of Tulsa West Maintenance Yard, which includes a public access CNG station. As shown in Figure 22-1, an oil refinery is located just south of West 25th Street South. Another refinery is located to the northwest of the site, on the other side of I-244. A rail yard is also located on the west side of I-244, which can be seen on left-hand side of Figure 22-1.

TMOK is located in north Tulsa on the property of Fire Station Number 24. As shown in Figure 22-2, the intersection of North Peoria Avenue (Highway 11) and East 36th Street North lies just to the northeast of the site. The surrounding area is primarily residential, with wooded areas just to the east, an early childhood education facility and an elementary school to the south, and a park to the west.

The TROK monitoring site is located west of downtown Tulsa, less than one-half mile north of the Arkansas River and north-northwest of the TOOK site. Although the area surrounding the TROK monitoring site is classified as “industrial”, the site is immediately adjacent to a residential dwelling, less than one-quarter mile south of Highway 412/51 (Sand Springs Expressway). The site is elevated above the river, and a wooded area separates the residential area from the industrial areas west of Newblock Park, as shown in Figure 22-3.

Figure 22-4 shows that the Tulsa sites are located roughly 5 miles apart, with TMOK farthest north and TOOK farthest south. Many of the emissions sources are clustered around TOOK, while there are no point sources within 2 miles of TMOK. There are a variety of industries in the area although the source category with the greatest number of sources surrounding the Tulsa sites is the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. Point sources closest to TOOK include two petroleum refineries (including one directly under the star symbol for TOOK); a rail yard; a municipal waste combustor; a compressor station; a metal coating, engraving, and allied services to manufacturers facility; an airport/airport support operation; and a facility generating electricity via combustion. The closest

point source to TROK is a refinery located on the other side of the Arkansas River, according to Figure 22-4. However, several industrial facilities are located between the site and river but are not included in the NEI for point sources.

The ADOK monitoring site is located on the property of the Oklahoma City Police Department firing range, approximately one-half mile south of I-240. The area is considered commercial although the immediate area surrounding ADOK is open, with a residential subdivision located farther west, as shown in Figure 22-5. This site lies northwest of Stanley Draper Lake and is surrounded by grasslands, with little activity or traffic in the immediate vicinity. The monitoring site was established at this location to capture any influence from Tinker Air Force Base and to collect background data (OK DEQ, 2013), although sampling was discontinued in June 2013.

OCOK is located in northern Oklahoma City, on the property of Oklahoma Christian University of Science and Arts. The site is located in the northwest corner of the University, near the athletic fields. The areas surrounding the university are primarily residential. Heavily traveled roadways such as I-35 and I-44 to the east and John Kilpatrick Turnpike to the south are within a few miles of the site, although outside the boundaries of Figure 22-6.

The instrumentation at ADOK was relocated to the YUOK location in July 2013. This is the location of an existing monitoring site for Oklahoma Department of Environmental Quality (ODEQ) in Yukon, a town to the west of Oklahoma City and in neighboring Canadian County. The monitoring site is located at the Integris water tower, just south of I-40. The site is located in a primarily commercial area, although the area north of I-40 is highly residential while the area to the south is of mixed usage. An oil well pump jack is located to the southwest of YUOK, which is shown in the middle of the green field to the southwest of YUOK in Figure 22-7. Yukon is a rapidly growing area, with both commercial and residential development.

Figure 22-8 shows that the locations of the ADOK, OCOK, and YUOK monitoring sites form a triangle around Oklahoma City. The outer boundary of each site's 10-mile radius intersects the other two sites. Most of the point sources located within 10 miles of the three sites are located between the sites in the center of Oklahoma City (northwest of ADOK, south of OCOK, and west of YUOK). The source category with the greatest number of sources

surrounding these sites is the airport source category. The point source closest to ADOK is Tinker Air Force Base, which lies just on the other side of I-240. The source closest to OCOK is involved in brick, structural clay, or clay ceramics. The source closest to YUOK is an oil and gas production facility, although a chemical manufacturing facility is located roughly the same distance away.

Table 22-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Oklahoma monitoring sites. Table 22-2 includes both county-level population and vehicle registration information. Table 22-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 22-2 presents the county-level daily VMT for Tulsa, Oklahoma, and Canadian Counties.

Table 22-2. Population, Motor Vehicle, and Traffic Information for the Oklahoma Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
TOOK	Tulsa	622,409	614,543	64,424	I-244 at Southwest Blvd	20,453,745
TMOK				12,500	Near E 36th St N and N Peoria Ave intersection	
TROK				56,200	64/51/412 just west of I-244	
ADOK	Oklahoma	755,245	835,642	34,700	I-240 between I-35 and I-40	27,469,678
OCOK				41,500	US-77 north of Turnpike	
YUOK	Canadian	126,123	106,000	45,400	I-40 west of Hwy 4	4,457,374

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect 2013 data (OKTC, 2013)

³AADT reflects 2012 data (OK DOT, 2012)

⁴County-level VMT reflects 2013 data (OK DOT, 2014)

Observations from Table 22-2 include the following:

- The Canadian County population is significantly less than the populations for Tulsa and Oklahoma Counties. Compared to other NMP monitoring sites, the Tulsa and Oklahoma County populations are in the middle of the range, while Canadian County's population is on the lower end.
- The Canadian County vehicle registration is also significantly less than vehicle registrations for Tulsa and Oklahoma Counties. Compared to other NMP sites, the Oklahoma County vehicle ownership is in the top third while the vehicle ownership

for Tulsa County is in the middle third and Canadian County's vehicle ownership is in the bottom third.

- The traffic volume passing the TMOK site is the lowest among the Oklahoma monitoring sites while the traffic passing by TOOK is the highest of the six sites. The traffic data for TOOK is in the top third while the traffic volumes for the remaining Oklahoma sites are in the middle third compared to other NMP sites.
- County-level VMT is greatest for Oklahoma County and ranks 12th compared to other NMP sites. VMT is the least for Canadian County and ranks 35th compared to other NMP sites. The VMT for Tulsa County ranks 18th.

22.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Oklahoma on sample days, as well as over the course of the year.

22.2.1 Climate Summary

Tulsa is located in northeast Oklahoma, just southeast of the Osage Indian Reservation, and along the Arkansas River. Oklahoma City is located in the center of the state. These areas are characterized by a continental climate, with long, warm summers and relatively mild winters. Precipitation is generally concentrated in the spring and summer months, with maximum precipitation occurring in May, June, and September, although precipitation amounts generally decrease across the state from east to west. Spring and summer precipitation usually results from showers and thunderstorms, while fall and winter precipitation accompanies frontal systems. Annual snowfall in these areas is less than 10 inches per year. Drought conditions are not uncommon. A southerly wind prevails for much of the year. Oklahoma is part of "Tornado Alley," where severe thunderstorms capable of producing strong winds, hail, and tornadoes occur more frequently than other areas around the country; tornadoes are more prevalent here than any other region in the U.S. (Wood, 2004; NCDC, 2015; NOAA, 2015b).

22.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the Oklahoma monitoring sites (NCDC, 2013), as described in Section 3.4.2. The closest weather stations to the Tulsa sites are located at Richard Lloyd Jones Jr. Airport (near TOOK) and Tulsa International Airport (near TMOK and TROK), WBANs 53908 and 13968, respectively. The two closest weather stations to the Oklahoma City sites are located at Tinker

Air Force Base Airport (near ADOK) and Wiley Post Airport (near OCOK and YUOK), WBANs 13919 and 03954, respectively. Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 22-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 22-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 22-3 is the 95 percent confidence interval for each parameter. As shown in Table 22-3, average meteorological conditions on sample days appear cooler and slightly more humid at the Tulsa monitoring sites, although the differences are not statistically significant. Among the Oklahoma City sites, the differences are greatest for ADOK, where sample days appear cooler than conditions experienced throughout the year, but the difference is not statistically significant. Sampling was discontinued at ADOK at the end of June 2013, thereby missing the warmest months of the year. The opposite is true for YUOK, where sampling did not begin until July 2013, thereby missing the coldest months of the year. The average wind speed on sample days near YUOK is lower than the full-year average wind speed. Near OCOK, where sampling occurred year-round, sample days appear slightly cooler and more humid, similar to the Tulsa sites. The Oklahoma City area is the windiest location among NMP sites in 2013.

Table 22-3. Average Meteorological Conditions near the Oklahoma Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Public Works, Tulsa, Oklahoma - TOOK									
Richard Lloyd Jones Jr. Airport 53908 (36.04, -95.98)	6.1 miles	Sample Days (64)	68.0 ± 4.9	57.7 ± 4.7	46.0 ± 4.8	51.7 ± 4.3	68.0 ± 2.9	1018.5 ± 1.8	5.1 ± 0.6
	172° (S)	2013	70.5 ± 1.9	59.5 ± 1.9	46.9 ± 1.9	52.9 ± 1.7	66.6 ± 1.2	1017.9 ± 0.7	5.2 ± 0.3
Fire Station, Tulsa, Oklahoma - TMOK									
Tulsa International Airport 13968 (36.20, -95.89)	5.0 miles	Sample Days (63)	67.3 ± 5.0	57.9 ± 4.8	46.1 ± 4.8	51.7 ± 4.4	68.0 ± 3.3	1017.6 ± 1.9	7.9 ± 0.7
	94° (E)	2013	69.6 ± 1.9	59.6 ± 1.9	46.8 ± 1.9	52.9 ± 1.7	65.9 ± 1.3	1016.9 ± 0.7	8.1 ± 0.3
Riverside, Tulsa, Oklahoma - TROK									
Tulsa International Airport 13968 (36.20, -95.89)	7.8 miles	Sample Days (64)	68.2 ± 5.0	58.7 ± 4.9	46.7 ± 4.8	52.4 ± 4.4	67.6 ± 3.2	1017.6 ± 1.9	7.7 ± 0.7
	67° (ENE)	2013	69.6 ± 1.9	59.6 ± 1.9	46.8 ± 1.9	52.9 ± 1.7	65.9 ± 1.3	1016.9 ± 0.7	8.1 ± 0.3
Air Depot, Oklahoma City, Oklahoma - ADOK									
Tinker AFB/Airport 13919 (35.42, -97.38)	2.8 miles	Sample Days (31)	63.9 ± 6.2	54.9 ± 6.1	45.1 ± 6.3	49.9 ± 5.6	72.9 ± 5.5	1015.9 ± 2.1	9.8 ± 1.1
	27° (NNE)	2013	69.9 ± 1.9	59.5 ± 1.8	47.7 ± 1.9	53.2 ± 1.7	68.5 ± 1.5	1017.2 ± 0.7	9.4 ± 0.4

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 22-3. Average Meteorological Conditions near the Oklahoma Monitoring Sites (Continued)

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Oklahoma City, Oklahoma - OCOK									
Wiley Post Airport 03954 (35.53, -97.65)	11.1 miles	Sample Days (63)	66.5 ± 5.0	57.1 ± 4.9	42.9 ± 4.6	49.7 ± 4.3	62.1 ± 3.1	1017.4 ± 1.9	9.4 ± 0.8
	240° (WSW)	2013	69.7 ± 1.9	59.5 ± 1.9	44.4 ± 1.8	51.6 ± 1.7	60.6 ± 1.3	1016.5 ± 0.7	10.1 ± 0.4
Yukon, Oklahoma - YUOK									
Wiley Post Airport 03954 (35.53, -97.65)	7.0 miles	Sample Days (33)	72.2 ± 7.5	62.5 ± 7.4	46.7 ± 6.9	53.8 ± 6.3	59.2 ± 3.9	1019.0 ± 2.8	8.4 ± 1.0
	57° (ENE)	2013	69.7 ± 1.9	59.5 ± 1.9	44.4 ± 1.8	51.6 ± 1.7	60.6 ± 1.3	1016.5 ± 0.7	10.1 ± 0.4

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

22.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations at Richard Lloyd Jones Jr. Airport (for TOOK), Tulsa International Airport (for TMOK and TROK), Tinker Air Force Base (for ADOK), and Wiley Post Airport (for OCOK and TUOK) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

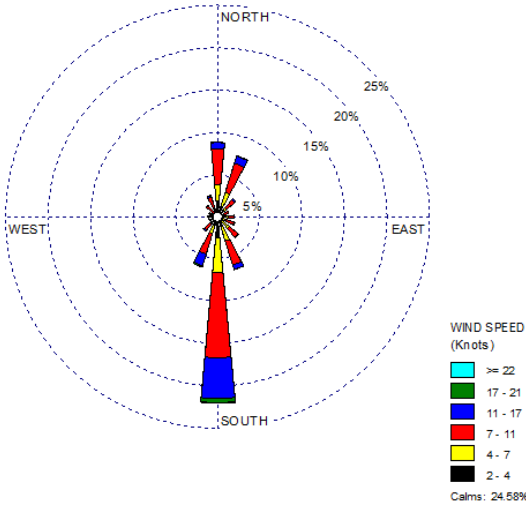
Figure 22-9 presents a map showing the distance between the weather station and TOOK, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 22-9 also presents three different wind roses for the TOOK monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind observations for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 22-10 through 22-14 present the distance maps and wind roses for the remaining Oklahoma sites.

**Figure 22-9. Wind Roses for the Richard Lloyd Jones Jr. Airport Weather Station near
TOOK**

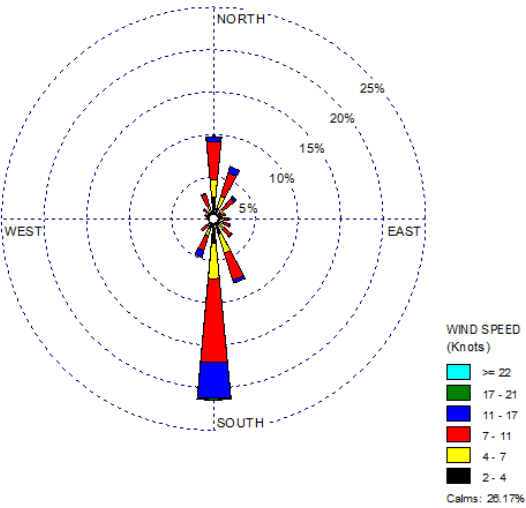
Location of TOOK and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

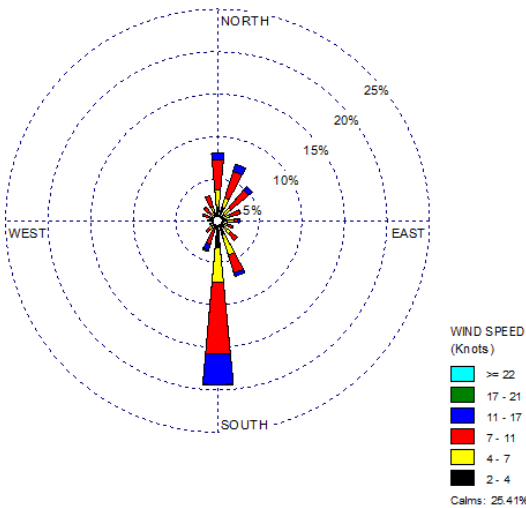
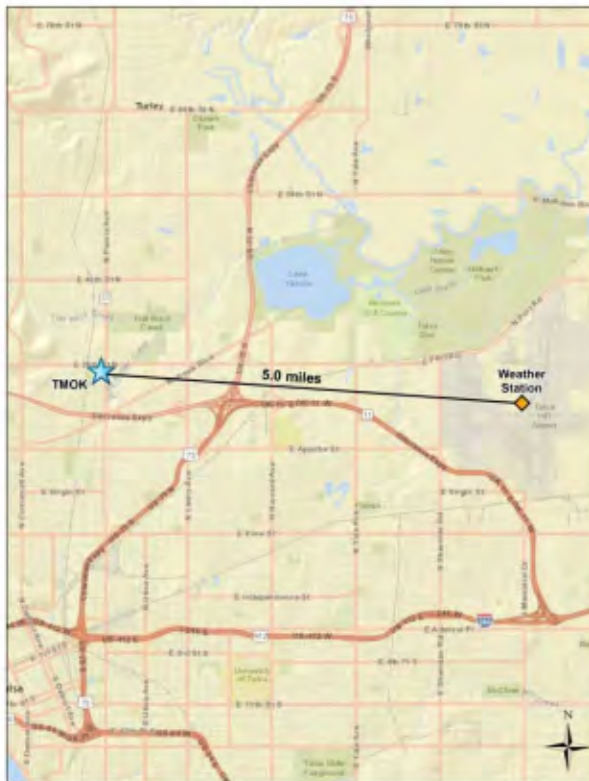
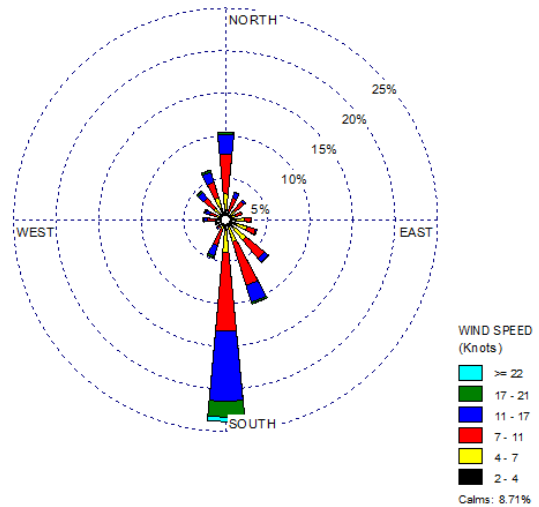


Figure 22-10. Wind Roses for the Tulsa International Airport Weather Station near TMOK

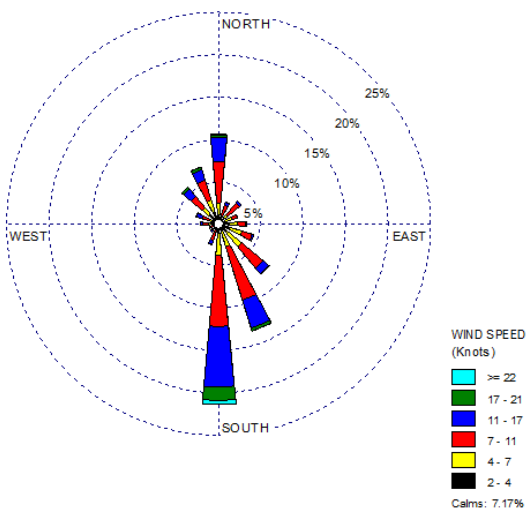
Location of TMOK and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

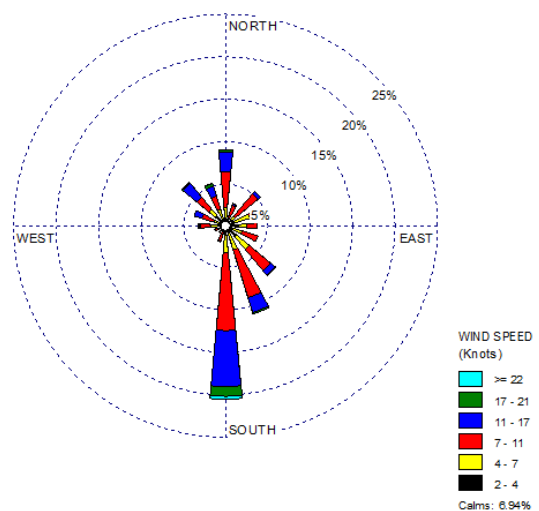
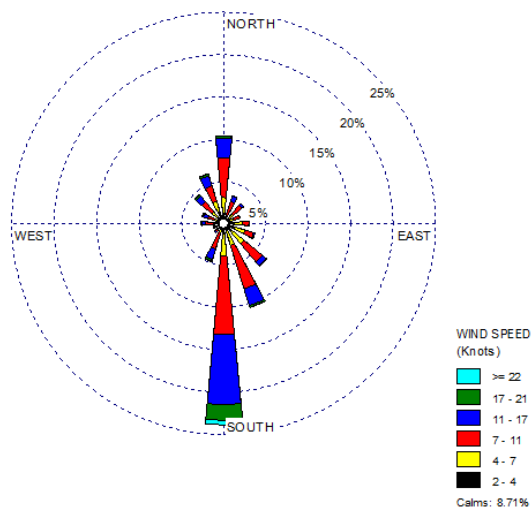


Figure 22-11. Wind Roses for the Tulsa International Airport Weather Station near TROK

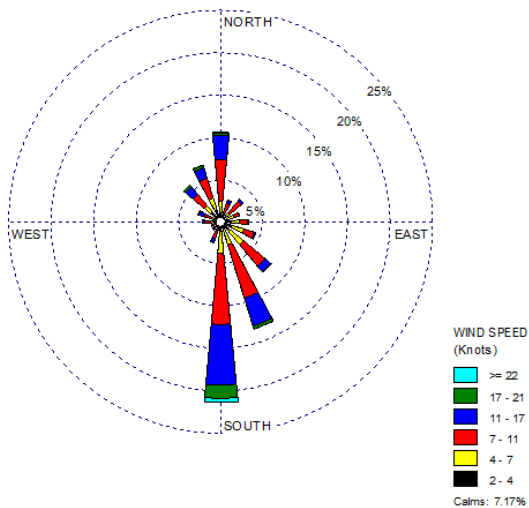
Location of TROK and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

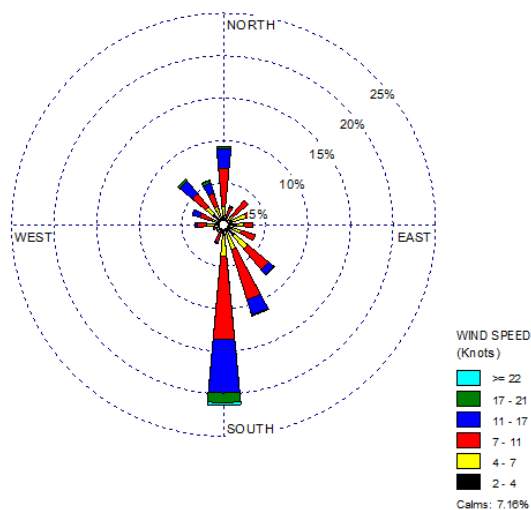
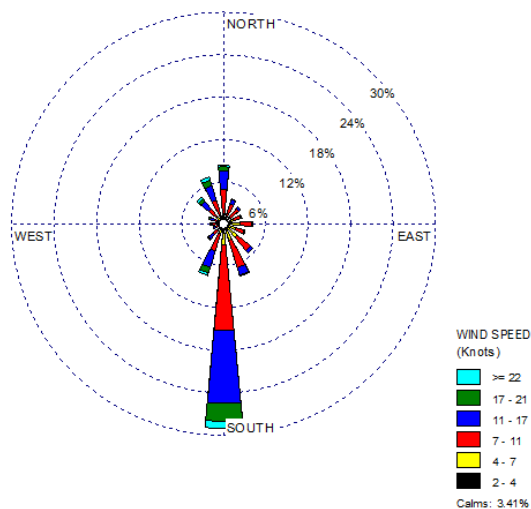


Figure 22-12. Wind Roses for the Tinker Air Force Base Airport Weather Station near ADOK

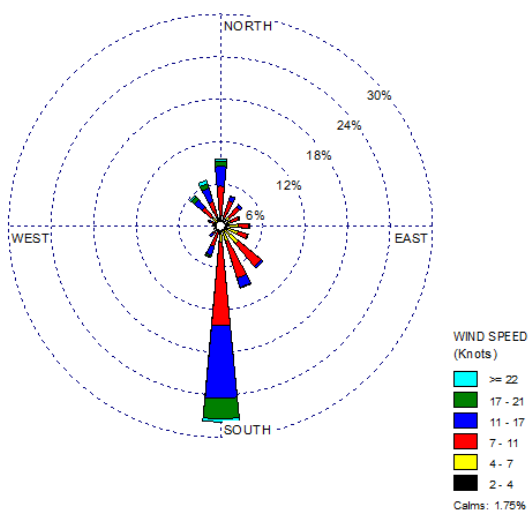
Location of ADOK and Weather Station



2006-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

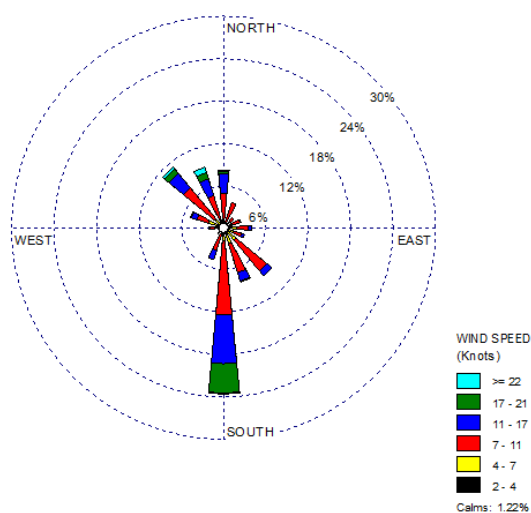
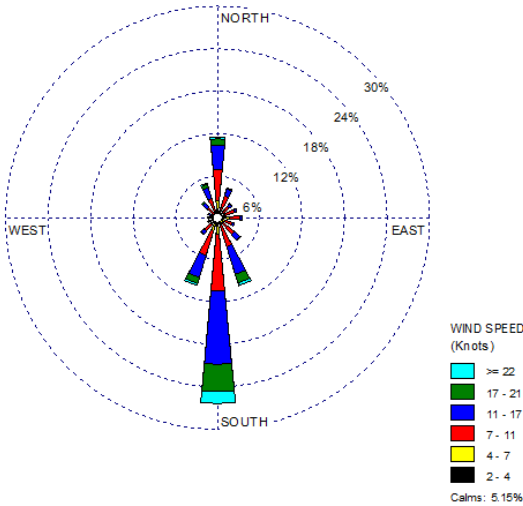


Figure 22-13. Wind Roses for the Wiley Post Airport Weather Station near OCOK

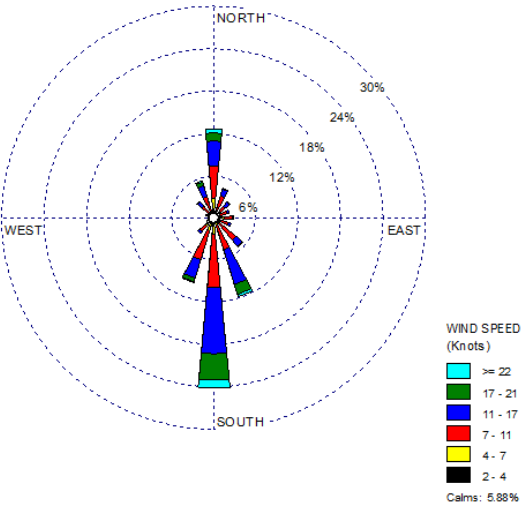
Location of OCOK and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

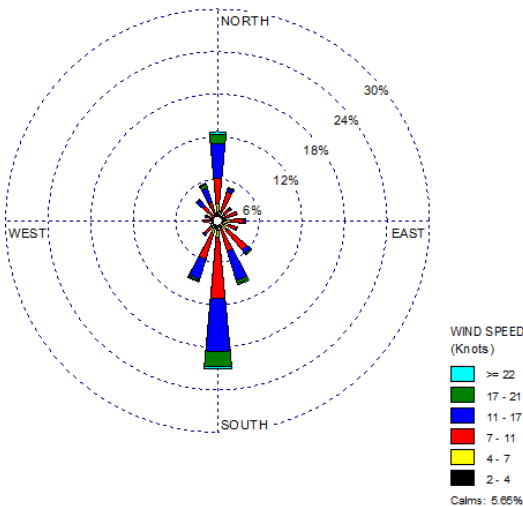
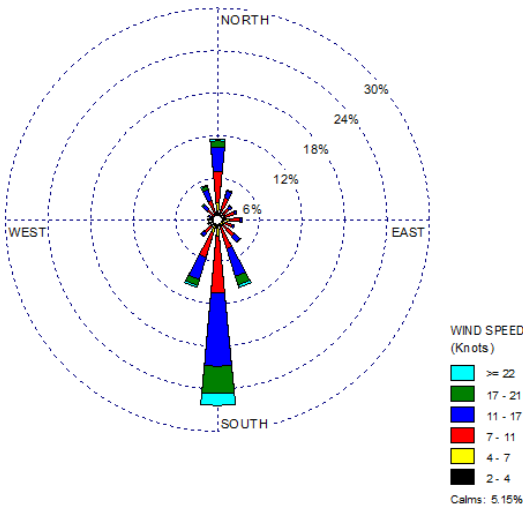


Figure 22-14. Wind Roses for the Wiley Post Airport Weather Station near YUOK

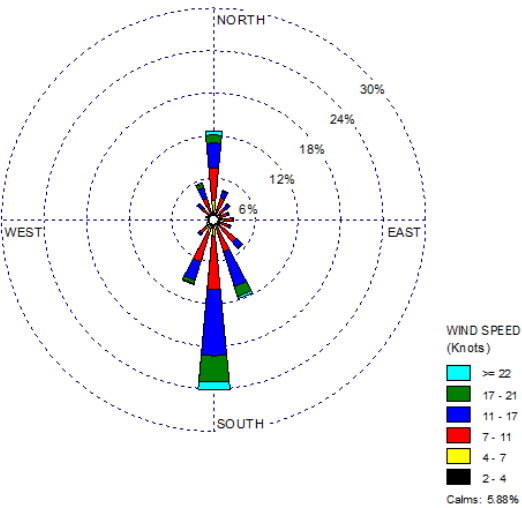
Location of YUOK and Weather Station



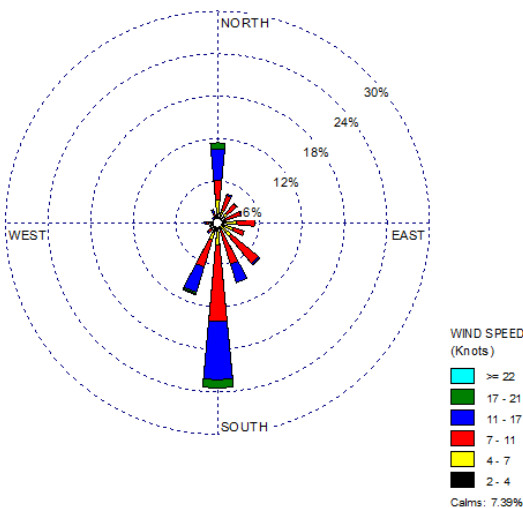
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figures 22-9 through 22-14 include the following:

- The maps show that the distances between the sites and the weather stations varies from 2.8 miles between Tinker Air Force Base and ADOK to 11.1 miles between OCOK and the Wiley Post Airport.
- Even though the historical data are from four different weather stations, the wind patterns shown on the wind roses for the Oklahoma sites are similar to each other. Each of the historical wind roses shows that southerly winds prevailed near each Oklahoma monitoring site, accounting for roughly 20 percent to 30 percent of observations among the historical time periods. The historical wind roses varied in the percentage of calm winds (those less than or equal to 2 knots) observed, ranging from as little as 3 percent at the Tinker Air Force Base (ADOK) to as high as 25 percent at the Richard Lloyd Jones Jr. Airport (TOOK). Calms winds, winds from the south-southeast to south-southwest, and winds from the north-northwest to north-northeast account for the majority of wind observations at each site while winds from the west or east were rarely observed near each site.
- For TOOK, the 2013 wind patterns are similar to the historical wind patterns, as are the sample day wind patterns, although there are slightly fewer southerly winds and winds from the north to northeast were observed more evenly on sample days. These similarities indicate that conditions on sample days were representative of those experienced over the entire year and historically.
- For TMOK, the 2013 wind patterns are similar to the historical wind patterns, although a higher percentage of south-southeasterly winds was observed in 2013. The sample day wind rose also resembles the historical and full-year wind roses, although a slightly higher percentage of northwesterly winds and lower percentage of north-northwesterly winds were observed on sample days. The percentage of calm winds shown for the full-year and sample day wind roses is slightly less than the percentage shown on the historical wind rose.
- The weather station closest to TROK is also located at the Tulsa International Airport; as such, the historical and full-year wind roses for TROK are identical to those shown for TMOK. The sample day wind patterns near TROK are also similar to those shown for TMOK.
- For ADOK, the historical wind rose includes 7 years of data, starting with 2006. The 2013 wind patterns resemble the historical wind patterns, although there were slightly more southeasterly to south-southeasterly wind observations in 2013 and fewer south-southwesterly winds. The calm wind rate also decreased by almost half. The sample day wind patterns exhibit additional differences, although southerly winds still prevailed. The percentage of northwesterly to north-northwesterly winds on sample days is more than twice the percentage shown on the full-year and historical wind roses. Winds from the south were observed less frequently on sample days and the calm rate is just greater than 1 percent. Recall, however, that sampling was discontinued at this site at the end of June; thus, the sample day wind rose includes observations from the first half of the year only.

- For OCOK, the wind patterns shown on the 2013 wind rose resemble the historical wind patterns. The sample day wind rose for OCOK is similar to both the historical and full-year wind roses, although winds greater than 22 knots account for a lower percentage of wind observations on sample days.
- The weather station closest to YUOK is also located at the Wiley Post Airport; as such, the historical and full-year wind roses for YUOK are identical to those shown for OCOK. The sample day wind rose for YUOK is similar to the sample day wind rose for OCOK, with winds greater than 22 knots also accounting for a lower percentage of wind observations on sample days. In addition, winds from the southeast and south-southeast were observed nearly equally and the calm rate is higher. Recall, however, that sampling at YUOK did not begin until July; thus, the sample day wind rose includes observations from the second half of the year only.

22.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Oklahoma monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 22-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 22-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. VOCs, carbonyl compounds, and metals (TSP) were sampled for at each Oklahoma monitoring site.

Table 22-4. Risk-Based Screening Results for the Oklahoma Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Public Works, Tulsa, Oklahoma - TOOK						
Acetaldehyde	0.45	61	61	100.00	12.35	12.35
Benzene	0.13	61	61	100.00	12.35	24.70
Carbon Tetrachloride	0.17	61	61	100.00	12.35	37.04
Formaldehyde	0.077	61	61	100.00	12.35	49.39
Arsenic (TSP)	0.00023	57	58	98.28	11.54	60.93
1,3-Butadiene	0.03	57	57	100.00	11.54	72.47
1,2-Dichloroethane	0.038	34	34	100.00	6.88	79.35
Ethylbenzene	0.4	29	61	47.54	5.87	85.22
Manganese (TSP)	0.03	22	58	37.93	4.45	89.68
Nickel (TSP)	0.0021	22	58	37.93	4.45	94.13
Hexachloro-1,3-butadiene	0.045	10	13	76.92	2.02	96.15
Propionaldehyde	0.8	8	61	13.11	1.62	97.77
<i>p</i> -Dichlorobenzene	0.091	5	40	12.50	1.01	98.79
Cadmium (TSP)	0.00056	3	58	5.17	0.61	99.39
Chloroprene	0.0021	1	1	100.00	0.20	99.60
1,2-Dibromoethane	0.0017	1	1	100.00	0.20	99.80
Lead (TSP)	0.015	1	58	1.72	0.20	100.00
Total		494	802	61.60		
Fire Station, Tulsa, Oklahoma - TMOK						
Acetaldehyde	0.45	61	61	100.00	12.71	12.71
Formaldehyde	0.077	61	61	100.00	12.71	25.42
Benzene	0.13	60	60	100.00	12.50	37.92
Carbon Tetrachloride	0.17	60	60	100.00	12.50	50.42
1,3-Butadiene	0.03	57	59	96.61	11.88	62.29
Arsenic (TSP)	0.00023	54	56	96.43	11.25	73.54
1,2-Dichloroethane	0.038	35	35	100.00	7.29	80.83
<i>p</i> -Dichlorobenzene	0.091	34	51	66.67	7.08	87.92
Ethylbenzene	0.4	25	60	41.67	5.21	93.13
Hexachloro-1,3-butadiene	0.045	13	14	92.86	2.71	95.83
Nickel (TSP)	0.0021	7	56	12.50	1.46	97.29
Propionaldehyde	0.8	7	61	11.48	1.46	98.75
Manganese (TSP)	0.03	3	56	5.36	0.63	99.38
Cadmium (TSP)	0.00056	2	56	3.57	0.42	99.79
Trichloroethylene	0.2	1	8	12.50	0.21	100.00
Total		480	754	63.66		

Table 22-4. Risk-Based Screening Results for the Oklahoma Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Riverside, Tulsa, Oklahoma - TROK						
Acetaldehyde	0.45	61	61	100.00	13.41	13.41
Benzene	0.13	61	61	100.00	13.41	26.81
Formaldehyde	0.077	61	61	100.00	13.41	40.22
Carbon Tetrachloride	0.17	60	61	98.36	13.19	53.41
1,3-Butadiene	0.03	54	56	96.43	11.87	65.27
Arsenic (TSP)	0.00023	53	56	94.64	11.65	76.92
1,2-Dichloroethane	0.038	40	40	100.00	8.79	85.71
Ethylbenzene	0.4	28	61	45.90	6.15	91.87
Nickel (TSP)	0.0021	11	56	19.64	2.42	94.29
Hexachloro-1,3-butadiene	0.045	10	11	90.91	2.20	96.48
Manganese (TSP)	0.03	6	56	10.71	1.32	97.80
Propionaldehyde	0.8	4	61	6.56	0.88	98.68
Cadmium (TSP)	0.00056	3	56	5.36	0.66	99.34
<i>p</i> -Dichlorobenzene	0.091	3	28	10.71	0.66	100.00
Total		455	725	62.76		
Air Depot, Oklahoma City, Oklahoma - ADOK						
Acetaldehyde	0.45	30	30	100.00	13.51	13.51
Benzene	0.13	30	30	100.00	13.51	27.03
Carbon Tetrachloride	0.17	30	30	100.00	13.51	40.54
Formaldehyde	0.077	30	30	100.00	13.51	54.05
1,2-Dichloroethane	0.038	28	28	100.00	12.61	66.67
<i>p</i> -Dichlorobenzene	0.091	27	29	93.10	12.16	78.83
Arsenic (TSP)	0.00023	25	29	86.21	11.26	90.09
1,3-Butadiene	0.03	11	16	68.75	4.95	95.05
Hexachloro-1,3-butadiene	0.045	5	5	100.00	2.25	97.30
Nickel (TSP)	0.0021	3	29	10.34	1.35	98.65
Manganese (TSP)	0.03	2	29	6.90	0.90	99.55
Propionaldehyde	0.8	1	30	3.33	0.45	100.00
Total		222	315	70.48		

Table 22-4. Risk-Based Screening Results for the Oklahoma Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Oklahoma City, Oklahoma - OCOK						
Acetaldehyde	0.45	61	61	100.00	14.52	14.52
Benzene	0.13	61	61	100.00	14.52	29.05
Carbon Tetrachloride	0.17	61	61	100.00	14.52	43.57
Formaldehyde	0.077	61	61	100.00	14.52	58.10
Arsenic (TSP)	0.00023	51	61	83.61	12.14	70.24
1,2-Dichloroethane	0.038	51	51	100.00	12.14	82.38
1,3-Butadiene	0.03	37	40	92.50	8.81	91.19
Hexachloro-1,3-butadiene	0.045	15	16	93.75	3.57	94.76
<i>p</i> -Dichlorobenzene	0.091	6	39	15.38	1.43	96.19
Ethylbenzene	0.4	6	61	9.84	1.43	97.62
Manganese (TSP)	0.03	3	61	4.92	0.71	98.33
Nickel (TSP)	0.0021	2	61	3.28	0.48	98.81
Propionaldehyde	0.8	2	61	3.28	0.48	99.29
Bromomethane	0.5	1	47	2.13	0.24	99.52
Cadmium (TSP)	0.00056	1	61	1.64	0.24	99.76
Trichloroethylene	0.2	1	7	14.29	0.24	100.00
Total		420	810	51.85		
Yukon, Oklahoma - YUOK						
Acetaldehyde	0.45	30	30	100.00	14.78	14.78
Benzene	0.13	30	30	100.00	14.78	29.56
Carbon Tetrachloride	0.17	30	30	100.00	14.78	44.33
Formaldehyde	0.077	30	30	100.00	14.78	59.11
Arsenic (TSP)	0.00023	26	31	83.87	12.81	71.92
1,3-Butadiene	0.03	21	22	95.45	10.34	82.27
1,2-Dichloroethane	0.038	20	20	100.00	9.85	92.12
Hexachloro-1,3-butadiene	0.045	7	9	77.78	3.45	95.57
<i>p</i> -Dichlorobenzene	0.091	5	15	33.33	2.46	98.03
Manganese (TSP)	0.03	3	31	9.68	1.48	99.51
1,2-Dibromoethane	0.0017	1	1	100.00	0.49	100.00
Total		203	249	81.53		

Observations from Table 22-4 include the following:

- Seventeen pollutants failed at least one screen for TOOK; nearly 62 percent of concentrations for these 17 pollutants were greater than their associated risk screening value (or failed screens).

- Eleven pollutants contributed to 95 percent of failed screens for TOOK and therefore were identified as pollutants of interest for this site. These 11 include two carbonyl compounds, six VOCs, and three TSP metals. TOOK is one of only two NMP sites for which manganese was identified as a pollutant of interest.
- Fifteen pollutants failed at least one screen for TMOK; nearly 64 percent of concentrations for these 15 pollutants were greater than their associated risk screening value (or failed screens).
- Ten pollutants contributed to 95 percent of failed screens for TMOK and therefore were identified as pollutants of interest for this site. These 10 include two carbonyl compounds, seven VOCs, and one TSP metal.
- Fourteen pollutants failed at least one screen for TROK; 63 percent of concentrations for these 14 pollutants were greater than their associated risk screening value (or failed screens).
- Ten pollutants contributed to 95 percent of failed screens for TROK and therefore were identified as pollutants of interest for this site. These 10 include two carbonyl compounds, six VOCs, and two TSP metals.
- Twelve pollutants failed at least one screen for ADOK; 70 percent of concentrations for these 12 pollutants were greater than their associated risk screening value (or failed screens).
- Eight pollutants contributed to 95 percent of failed screens for ADOK and therefore were identified as pollutants of interest for this site. These eight include two carbonyl compounds, five VOCs, and one TSP metal.
- Sixteen pollutants failed at least one screen for OCOK; 52 percent of concentrations for these 16 pollutants were greater than their associated risk screening value (or failed screens).
- Ten pollutants contributed to 95 percent of failed screens for OCOK and therefore were identified as pollutants of interest for this site. These 10 include two carbonyl compounds, seven VOCs, and one TSP metal. Note that because *p*-dichlorobenzene and ethylbenzene failed the same number of screens, both pollutants were identified as pollutants of interest for OCOK.
- Eleven pollutants failed at least one screen for YUOK; nearly 82 percent of concentrations for these 11 pollutants were greater than their associated risk screening value (or failed screens).
- Eight pollutants contributed to 95 percent of failed screens for YUOK and therefore were identified as pollutants of interest for this site. These eight include two carbonyl compounds, five VOCs, and one TSP metal.

- The number of pollutants identified as pollutants of interest range from eight to 11 among the Oklahoma sites. These sites have seven pollutants of interest in common: acetaldehyde, arsenic, benzene, 1,3-butadiene, carbon tetrachloride, 1,2-dichloroethane, and formaldehyde.
- TOOK failed the fourth highest number of screens among NMP sites, with other Oklahoma sites ranking seventh (TMOK), 10th (TROK), and 12th (OCOK), as shown in Table 4-8. The ADOK and YUOK sites failed fewer screens, ranking much lower. However, sampling at these sites includes only half of a year's worth of samples.

22.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Oklahoma monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at the Oklahoma sites are provided in Appendices J, L, and N.

22.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Oklahoma site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal

to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Oklahoma monitoring sites are presented in Table 22-5, where applicable. Note that concentrations of the TSP metals are presented in ng/m³ for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 22-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Oklahoma Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
Public Works, Tulsa, Oklahoma - TOOK						
Acetaldehyde	61/61	1.45 ± 0.37	2.19 ± 0.56	2.93 ± 0.44	1.54 ± 0.30	2.02 ± 0.25
Benzene	61/61	1.22 ± 0.40	1.07 ± 0.26	1.64 ± 0.40	0.93 ± 0.24	1.21 ± 0.17
1,3-Butadiene	57/61	0.09 ± 0.04	0.05 ± 0.01	0.06 ± 0.02	0.10 ± 0.03	0.07 ± 0.01
Carbon Tetrachloride	61/61	0.61 ± 0.03	0.69 ± 0.05	0.64 ± 0.04	0.55 ± 0.06	0.63 ± 0.03
1,2-Dichloroethane	34/61	0.09 ± 0.04	0.05 ± 0.03	0.05 ± 0.03	0.07 ± 0.03	0.06 ± 0.02
Ethylbenzene	61/61	0.47 ± 0.16	0.42 ± 0.10	0.47 ± 0.11	0.42 ± 0.13	0.45 ± 0.06
Formaldehyde	61/61	2.05 ± 0.36	3.29 ± 1.12	4.58 ± 0.72	1.63 ± 0.32	2.87 ± 0.44
Hexachloro-1,3-butadiene	13/61	0.02 ± 0.02	0.01 ± 0.02	0.01 ± 0.01	0.03 ± 0.02	0.02 ± 0.01
Arsenic (TSP)	58/58	0.74 ± 0.13	0.76 ± 0.14	0.88 ± 0.15	0.71 ± 0.17	0.78 ± 0.07
Manganese (TSP)	58/58	23.25 ± 10.12	28.89 ± 9.66	31.88 ± 9.45	25.94 ± 10.78	27.59 ± 4.75
Nickel (TSP)	58/58	2.05 ± 0.74	2.05 ± 0.69	2.50 ± 1.29	1.70 ± 0.55	2.09 ± 0.42

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m³ for ease of viewing. NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Table 22-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Oklahoma Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
Fire Station, Tulsa, Oklahoma - TMOK						
Acetaldehyde	61/61	1.25 ± 0.30	2.14 ± 0.62	2.84 ± 0.44	1.55 ± 0.28	1.94 ± 0.25
Benzene	60/60	1.08 ± 0.27	0.69 ± 0.09	1.12 ± 0.23	1.00 ± 0.29	0.96 ± 0.12
1,3-Butadiene	59/60	0.11 ± 0.05	0.06 ± 0.01	0.10 ± 0.03	0.15 ± 0.05	0.11 ± 0.02
Carbon Tetrachloride	60/60	0.62 ± 0.05	0.66 ± 0.06	0.63 ± 0.03	0.56 ± 0.04	0.62 ± 0.02
<i>p</i> -Dichlorobenzene	51/60	0.04 ± 0.02	0.10 ± 0.05	0.15 ± 0.04	0.11 ± 0.02	0.10 ± 0.02
1,2-Dichloroethane	35/60	0.09 ± 0.03	0.08 ± 0.03	0.03 ± 0.02	0.04 ± 0.03	0.06 ± 0.01
Ethylbenzene	60/60	0.48 ± 0.23	0.28 ± 0.05	0.52 ± 0.13	0.47 ± 0.15	0.43 ± 0.07
Formaldehyde	61/61	2.07 ± 0.38	3.54 ± 1.30	4.59 ± 0.82	2.59 ± 0.36	3.19 ± 0.45
Hexachloro-1,3-butadiene	14/60	0.01 ± 0.02	0.01 ± 0.01	0.02 ± 0.02	0.03 ± 0.02	0.02 ± 0.01
Arsenic (TSP)	56/56	0.56 ± 0.13	0.65 ± 0.15	0.75 ± 0.14	0.61 ± 0.16	0.65 ± 0.07
Riverside, Tulsa, Oklahoma - TROK						
Acetaldehyde	61/61	1.14 ± 0.25	1.55 ± 0.39	2.38 ± 0.34	1.48 ± 0.34	1.63 ± 0.20
Benzene	61/61	1.32 ± 0.91	0.80 ± 0.16	0.99 ± 0.20	0.92 ± 0.28	1.00 ± 0.23
1,3-Butadiene	56/61	0.09 ± 0.03	0.05 ± 0.01	0.06 ± 0.01	0.10 ± 0.03	0.07 ± 0.01
Carbon Tetrachloride	61/61	0.59 ± 0.04	0.68 ± 0.05	0.63 ± 0.02	0.55 ± 0.07	0.61 ± 0.03
1,2-Dichloroethane	40/61	0.08 ± 0.03	0.07 ± 0.03	0.04 ± 0.02	0.08 ± 0.03	0.07 ± 0.01
Ethylbenzene	61/61	0.32 ± 0.11	0.35 ± 0.09	0.46 ± 0.10	0.45 ± 0.19	0.39 ± 0.06
Formaldehyde	61/61	1.71 ± 0.36	2.98 ± 1.00	4.51 ± 0.58	1.94 ± 0.33	2.77 ± 0.41
Hexachloro-1,3-butadiene	11/61	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.03 ± 0.02	0.01 ± 0.01
Arsenic (TSP)	56/56	0.77 ± 0.24	0.72 ± 0.26	0.83 ± 0.21	0.88 ± 0.27	0.80 ± 0.11
Nickel (TSP)	56/56	1.40 ± 0.55	1.14 ± 0.39	1.73 ± 0.51	1.45 ± 0.50	1.43 ± 0.24

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m³ for ease of viewing. NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Table 22-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Oklahoma Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Oklahoma City, Oklahoma - OCOK						
Acetaldehyde	61/61	1.15 ± 0.23	1.93 ± 0.49	2.72 ± 0.40	1.60 ± 0.33	1.85 ± 0.23
Benzene	61/61	0.83 ± 0.18	0.50 ± 0.06	0.61 ± 0.13	1.14 ± 1.14	0.78 ± 0.29
1,3-Butadiene	40/61	0.05 ± 0.03	0.02 ± 0.01	0.04 ± 0.02	0.06 ± 0.04	0.04 ± 0.01
Carbon Tetrachloride	61/61	0.63 ± 0.06	0.67 ± 0.05	0.63 ± 0.05	0.62 ± 0.02	0.64 ± 0.02
<i>p</i> -Dichlorobenzene	39/61	0.06 ± 0.02	0.04 ± 0.02	0.05 ± 0.02	0.03 ± 0.02	0.05 ± 0.01
1,2-Dichloroethane	51/61	0.09 ± 0.02	0.10 ± 0.03	0.05 ± 0.02	0.06 ± 0.02	0.08 ± 0.01
Ethylbenzene	61/61	0.24 ± 0.09	0.20 ± 0.04	0.28 ± 0.07	0.22 ± 0.07	0.23 ± 0.03
Formaldehyde	61/61	1.53 ± 0.30	2.80 ± 0.84	4.47 ± 0.63	1.78 ± 0.50	2.63 ± 0.41
Hexachloro-1,3-butadiene	16/61	0.02 ± 0.02	0.02 ± 0.02	0.01 ± 0.01	0.03 ± 0.02	0.02 ± 0.01
Arsenic (TSP)	61/61	0.32 ± 0.08	0.53 ± 0.13	0.60 ± 0.13	0.39 ± 0.10	0.46 ± 0.06
Air Depot, Oklahoma City, Oklahoma - ADOK						
Acetaldehyde	30/30	1.21 ± 0.19	1.97 ± 0.50	NA	NA	NA
Benzene	30/30	0.62 ± 0.09	0.43 ± 0.06	NA	NA	NA
1,3-Butadiene	16/30	0.03 ± 0.02	0.02 ± 0.02	NA	NA	NA
Carbon Tetrachloride	30/30	0.62 ± 0.05	0.65 ± 0.06	NA	NA	NA
<i>p</i> -Dichlorobenzene	29/30	0.12 ± 0.02	0.14 ± 0.01	NA	NA	NA
1,2-Dichloroethane	28/30	0.09 ± 0.02	0.10 ± 0.03	NA	NA	NA
Formaldehyde	30/30	1.67 ± 0.30	2.82 ± 0.78	NA	NA	NA
Arsenic (TSP)	29/29	0.32 ± 0.06	0.44 ± 0.12	NA	NA	NA

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing. NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Table 22-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Oklahoma Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Yukon, Oklahoma - YUOK						
Acetaldehyde	30/30	NA	NA	2.30 ± 0.27	1.30 ± 0.29	NA
Benzene	30/30	NA	NA	0.48 ± 0.05	0.52 ± 0.07	NA
1,3-Butadiene	22/30	NA	NA	0.04 ± 0.01	0.04 ± 0.02	NA
Carbon Tetrachloride	30/30	NA	NA	0.65 ± 0.04	0.59 ± 0.02	NA
1,2-Dichloroethane	20/30	NA	NA	0.06 ± 0.02	0.05 ± 0.02	NA
Formaldehyde	30/30	NA	NA	4.18 ± 0.52	1.78 ± 0.40	NA
Hexachloro-1,3-butadiene	9/30	NA	NA	0.02 ± 0.02	0.02 ± 0.02	NA
Arsenic (TSP)	31/31	NA	NA	0.51 ± 0.07	0.36 ± 0.11	NA

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing. NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations for the Oklahoma sites from Table 22-5 include the following:

- Formaldehyde has the highest annual average concentration for each site, where annual averages could be calculated, followed by acetaldehyde and benzene. With the exception of TOOK and TROK, these were the only two pollutants of interest with annual average concentrations greater than or equal to $1 \mu\text{g}/\text{m}^3$ for each site. For TOOK and TROK, benzene also has an annual average concentration greater than or equal to $1 \mu\text{g}/\text{m}^3$.
- Annual average concentrations of formaldehyde range from $2.63 \pm 0.41 \mu\text{g}/\text{m}^3$ for OCOK to $3.19 \pm 0.45 \mu\text{g}/\text{m}^3$ for TMOK. The annual average concentrations of acetaldehyde range from $1.63 \pm 0.20 \mu\text{g}/\text{m}^3$ for TROK to $2.02 \pm 0.25 \mu\text{g}/\text{m}^3$ for TOOK. The annual average concentrations of benzene range from $0.78 \pm 0.29 \mu\text{g}/\text{m}^3$ for OCOK to $1.21 \pm 0.17 \mu\text{g}/\text{m}^3$ for TOOK. TOOK has had the highest annual average benzene concentration among the Oklahoma sites for several years (and is usually one of the highest across the program), including 2013, although the difference is becoming less significant.
- Concentrations of the carbonyl compounds, formaldehyde in particular, tended to be highest in the warmer months and lowest in the cooler months. While concentrations were highest during the third quarter, the confidence intervals associated with the second quarter averages tended to be larger.

- The risk screening value for manganese increased from 0.005 $\mu\text{g}/\text{m}^3$ to 0.03 $\mu\text{g}/\text{m}^3$ for the 2013 report. As a result, this pollutant has significantly fewer failures in the 2013 report than in previous reports. For example, manganese failed only 61 screens for 2013 while failing 706 in the 2012 NMP report. Of the 61 failures for 2013, more than half were for concentrations measured at the Oklahoma sites (39). Of these 39, 22 were measured at TOOK, the only Oklahoma site (and one of only two NMP sites) for which manganese is a pollutant of interest. The other 17 break out as follows: two for ADOK, three for OCOK, three for TMOK, six for TROK, and three for YUOK.

Observations for TOOK from Table 22-5 include the following:

- Although the third quarter average formaldehyde concentration is the highest among the quarterly averages for TOOK, the confidence interval is larger for the second quarter average. The two highest formaldehyde concentrations were measured at TOOK on June 21, 2013 (7.91 $\mu\text{g}/\text{m}^3$) and June 27, 2013 (7.77 $\mu\text{g}/\text{m}^3$). Of the 13 formaldehyde concentrations greater than 4 $\mu\text{g}/\text{m}^3$ measured at TOOK, three were measured during the second quarter and 10 were measured during the third quarter.
- A similar observation can be made for the quarterly average concentrations of acetaldehyde. The maximum acetaldehyde concentration was measured at TOOK on June 27, 2013 (4.42 $\mu\text{g}/\text{m}^3$), while the next four highest concentrations were measured during the third quarter.
- The third quarter average concentration of nickel is the highest among TOOK's quarterly average concentrations of nickel and has a relatively large confidence interval associated with it. A review of the data shows that the maximum concentration of nickel was measured at TOOK on July 3, 2013 (11.0 ng/m^3). This measurement is nearly twice the next highest concentration (5.74 ng/m^3) measured at TOOK and more than three times greater than the next highest concentration measured during the third quarter. If the maximum concentration measured at TOOK was removed from the dataset, the third quarter average would be less than 2 ng/m^3 . This measurement is the third highest nickel concentration measured across the program.
- The third quarter average concentrations of the other two speciated metals are greater than each of their other quarterly averages, although not significantly so. A review of the data shows that the maximum concentrations of manganese (75.6 ng/m^3) and arsenic (1.51 ng/m^3) were measured at TOOK on the same day, September 25, 2013.

Observations for TMOK from Table 22-5 include the following:

- The second and third quarter average concentrations of formaldehyde are higher than the other quarterly averages for TMOK. Although the third quarter average concentration is the highest, the confidence interval is highest for the second quarter average concentration. A similar observation was made for concentrations of this pollutant measured at TOOK. A review of the data shows that the two highest formaldehyde concentrations were also measured at TMOK on June 21, 2013

(9.43 $\mu\text{g}/\text{m}^3$) and June 27, 2013 (7.78 $\mu\text{g}/\text{m}^3$). Of the 17 formaldehyde concentrations greater than 4 $\mu\text{g}/\text{m}^3$ measured at TMOK, five were measured during the second quarter and 10 were measured during the third quarter (with one each in the other calendar quarters). The minimum concentration of formaldehyde, the only one less than 1 $\mu\text{g}/\text{m}^3$, was also measured during the second quarter of 2013.

- A similar observation can be made for the quarterly average concentrations of acetaldehyde. The maximum acetaldehyde concentration was measured at TMOK on June 27, 2013 (4.75 $\mu\text{g}/\text{m}^3$), while the next five highest concentrations were measured during the third quarter. The minimum concentration of acetaldehyde was also measured during the second quarter of 2013.
- Several of the lowest quarterly average concentrations of the VOC pollutants of interest for TMOK (benzene, 1,3-butadiene, and ethylbenzene in particular) were calculated for the second quarter of 2013. In addition, these averages exhibit the least variability. A review of the benzene data shows that the range of measurements was smallest for the second quarter, that the median concentration was the lowest for the second quarter, and that the second quarter of 2013 had the fewest benzene concentrations greater than 1 $\mu\text{g}/\text{m}^3$ (only one, compared to five for the first quarter, eight for the third, and six for the fourth). For ethylbenzene, no concentrations greater than 0.5 $\mu\text{g}/\text{m}^3$ were measured during the second quarter while between four and six were measured in the other quarters. Similar observations can be made for 1,3-butadiene, where no concentrations greater than 0.1 $\mu\text{g}/\text{m}^3$ were measured at TMOK during the second quarter and between five and nine were measured during the other calendar quarters.
- Concentrations of *p*-dichlorobenzene were lowest during the first quarter of 2013 for TMOK. Six of the nine non-detects were measured during the first quarter of 2013 and none were measured at TMOK after April. In addition, five of the eight lowest measured detections (those less than 0.05 $\mu\text{g}/\text{m}^3$) were measured during the first quarter (and the other three were measured during the second quarter).
- Arsenic concentrations appear highest during the third quarter, although the quarterly averages shown in Table 22-5 are not significantly different. The two highest arsenic concentrations were measured at TMOK in July and August. Conversely, of the 18 arsenic concentrations less than 0.5 ng/m^3 measured at TMOK, only two were measured during the third quarter, compared to seven for the first quarter, five for the second, and four for the fourth.

Observations for TROK from Table 22-5 include the following:

- The second and third quarter average concentrations of formaldehyde are higher than the other quarterly averages for TROK. Although the third quarter average concentration is the highest, the confidence interval is highest for the second quarter. A similar observation was made for concentrations of this pollutant measured at TOOK and TMOK. A review of the data shows that the highest formaldehyde concentration was measured at TROK on June 27, 2013 (7.78 $\mu\text{g}/\text{m}^3$), the same date that the second highest concentrations of formaldehyde were measured at TOOK and

TMOK. Of the 15 formaldehyde concentrations greater than $4 \mu\text{g}/\text{m}^3$ measured at TROK, five were measured in June and 10 were measured during the third quarter. The minimum concentration of formaldehyde ($0.631 \mu\text{g}/\text{m}^3$) was also measured during the second quarter of 2013.

- Concentrations of acetaldehyde were highest during the third quarter of 2013 at TROK. The maximum acetaldehyde concentration was measured at TROK on September 1, 2013 ($3.90 \mu\text{g}/\text{m}^3$), which is also a day higher concentrations were measured at TOOK and TMOK. Of the 18 acetaldehyde concentrations greater than $2 \mu\text{g}/\text{m}^3$ measured at TROK, 11 were measured during the third quarter while three or less were measured during the other calendar quarters.
- The first quarter benzene concentration for TROK is higher than the other quarterly averages and has a relatively large confidence interval associated with it. The benzene concentration measured at TROK on January 16, 2013 ($7.43 \mu\text{g}/\text{m}^3$) is more than three times greater than the next highest benzene concentration measured at TROK ($2.31 \mu\text{g}/\text{m}^3$, measured on December 18, 2013). The maximum concentration measured at TROK is the third highest benzene concentration measured across the program.
- Several of the lowest quarterly average concentrations of the VOC pollutants of interest for TROK (benzene and 1,3-butadiene in particular) were calculated for the second quarter of 2013, similar to TMOK. In addition, these averages generally exhibit the least variability. A review of the benzene data shows that the range of measurements was smallest for the second quarter, that the median concentration was the lowest for the second quarter, and that the second quarter of 2013 had the fewest benzene concentrations greater than $1 \mu\text{g}/\text{m}^3$ (only two, compared to five for the first quarter, eight for the third, and four for the fourth). Similar observations can be made for 1,3-butadiene, where no concentrations greater than $0.1 \mu\text{g}/\text{m}^3$ were measured at TROK during the second quarter (or third quarter) while four were measured during the first quarter and seven were measured during the fourth quarter. There were three concentrations measured during the third quarter that are greater than the maximum concentration measured during the second quarter of 2013.

Observations for OCOK from Table 22-5 include the following:

- Similar to the Tulsa sites, the second and third quarter average concentrations of formaldehyde are higher than the other quarterly averages for OCOK, and although the third quarter average concentration is the highest, the confidence interval is highest for the second quarter. A review of the data shows that the two formaldehyde concentrations greater than $6 \mu\text{g}/\text{m}^3$ were measured at OCOK during the third quarter, while the next three highest were all measured in June (second quarter). Of the 13 formaldehyde concentrations greater than $4 \mu\text{g}/\text{m}^3$ measured at OCOK, three were measured in June and nine were measured during the third quarter (with the additional one in the fourth quarter). No formaldehyde concentrations greater than $4 \mu\text{g}/\text{m}^3$ were measured before June.

- The maximum acetaldehyde concentration was measured at OCOK on the same day as the maximum formaldehyde concentration (September 7, 2013). Acetaldehyde concentrations greater than $3 \mu\text{g}/\text{m}^3$ were all measured between June and October.
- The confidence interval associated with fourth quarter average benzene concentration for OCOK is similar in magnitude to the average itself, indicating that outliers may be affecting this average. A review of the data shows that the benzene concentration measured at OCOK on November 6, 2013 ($9.38 \mu\text{g}/\text{m}^3$) is nearly six times greater than the next highest benzene concentration measured at OCOK ($1.81 \mu\text{g}/\text{m}^3$, measured on January 4, 2013). This is the second highest benzene concentration measured across the program.
- Concentrations of 1,3-butadiene appear lowest during the second quarter of 2013, similar to the Tulsa sites. No concentrations greater than $0.1 \mu\text{g}/\text{m}^3$ were measured during the second quarter, while between one and three were measured in the other quarters. In addition, the second quarter has the highest number of non-detects at seven, although this is the same number measured during the fourth quarter.
- The quarterly average concentrations of arsenic are highest during the warmer months and have a higher level of variability associated with them. The only arsenic concentration greater than $1 \text{ ng}/\text{m}^3$ was measured at OCOK on July 3, 2013 ($1.03 \text{ ng}/\text{m}^3$) and seven of the eight arsenic concentrations greater than $0.75 \text{ ng}/\text{m}^3$ were measured between April and September.

Observations for ADOK and YUOK from Table 22-5 include the following:

- The instrumentation at ADOK was moved to YUOK mid-year; as a result, ADOK has only first and second quarter averages, YUOK has only third and fourth quarter averages, and neither site has annual averages in Table 22-5. However, site-specific statistical summaries for all pollutants sampled for at these sites for the time frame of sampling are available in Appendices J, L, and N.
- Formaldehyde and acetaldehyde have the highest quarterly averages among the pollutants of interest for these two sites, with the highest of the two available quarterly averages calculated for the quarter including samples collected during the warmer months of the year. Of the VOCs, carbon tetrachloride and benzene have the highest quarterly averages for these two sites.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Oklahoma sites include the following:

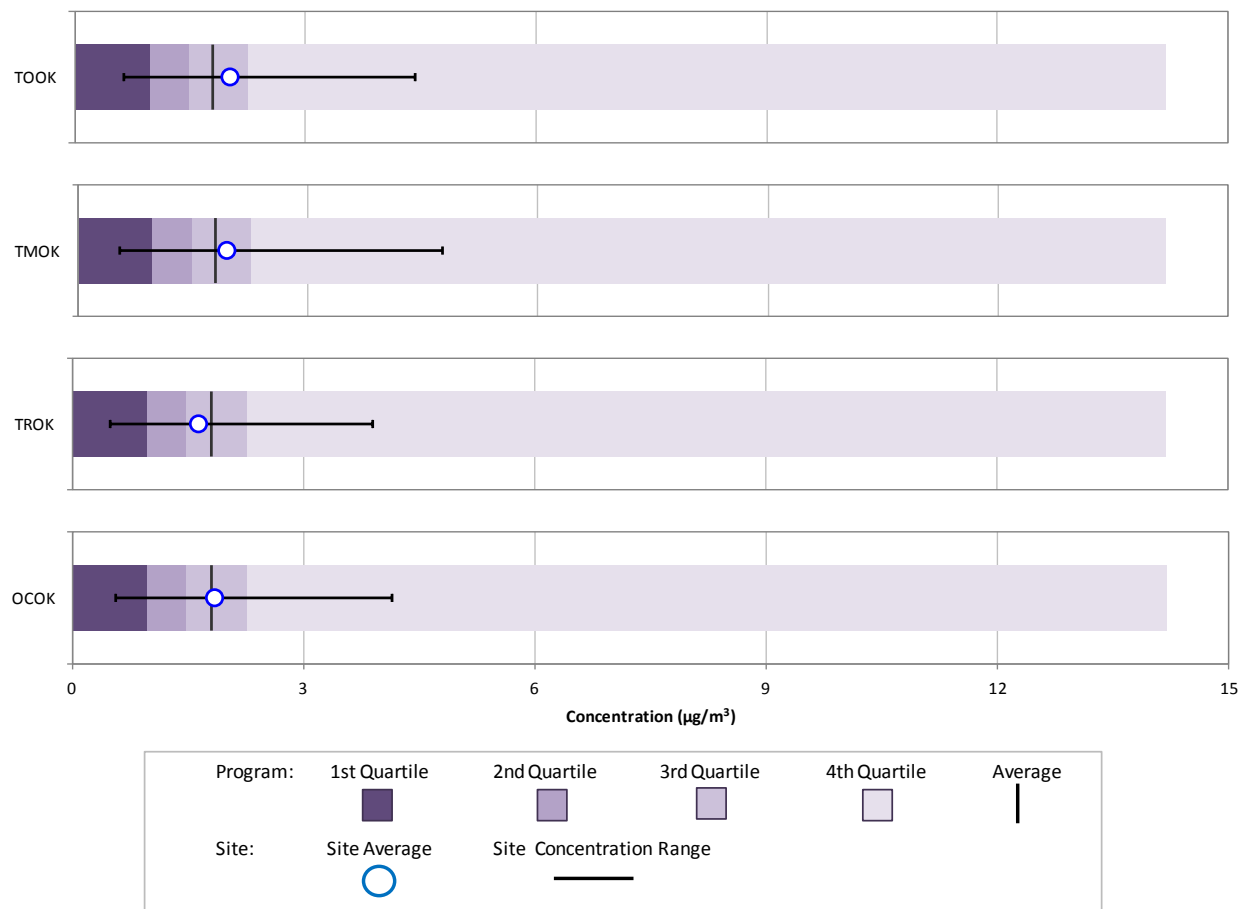
- The Oklahoma sites appear in Tables 4-9 through 4-12 a total of 19 times. However, because they are the only sites sampling TSP metals, four of the sites appear for each metal, accounting for eight of the appearances.

- All three Tulsa sites appear in Table 4-9 among the sites with the highest annual average concentrations of ethylbenzene, with TOOK ranking seventh, TMOK ranking eighth, and TROK ranking 10th.
- TOOK has the sixth highest annual average of concentration of benzene. OCOK appears in Table 4-9 for hexachloro-1,3-butadiene, ranking fourth highest. TMOK appears for *p*-dichlorobenzene, ranking third highest.
- TOOK and TMOK rank eighth and 10th, respectively for their annual average concentrations of acetaldehyde. Only TOOK appears in Table 4-10 for formaldehyde (ranking ninth).
- The Tulsa sites rank higher than OCOK for the two TSP metals shown in Table 4-12. TROK has the highest annual average arsenic concentration among the Oklahoma sites while TOOK highest annual average nickel concentration among the Oklahoma sites.

22.4.2 Concentration Comparison

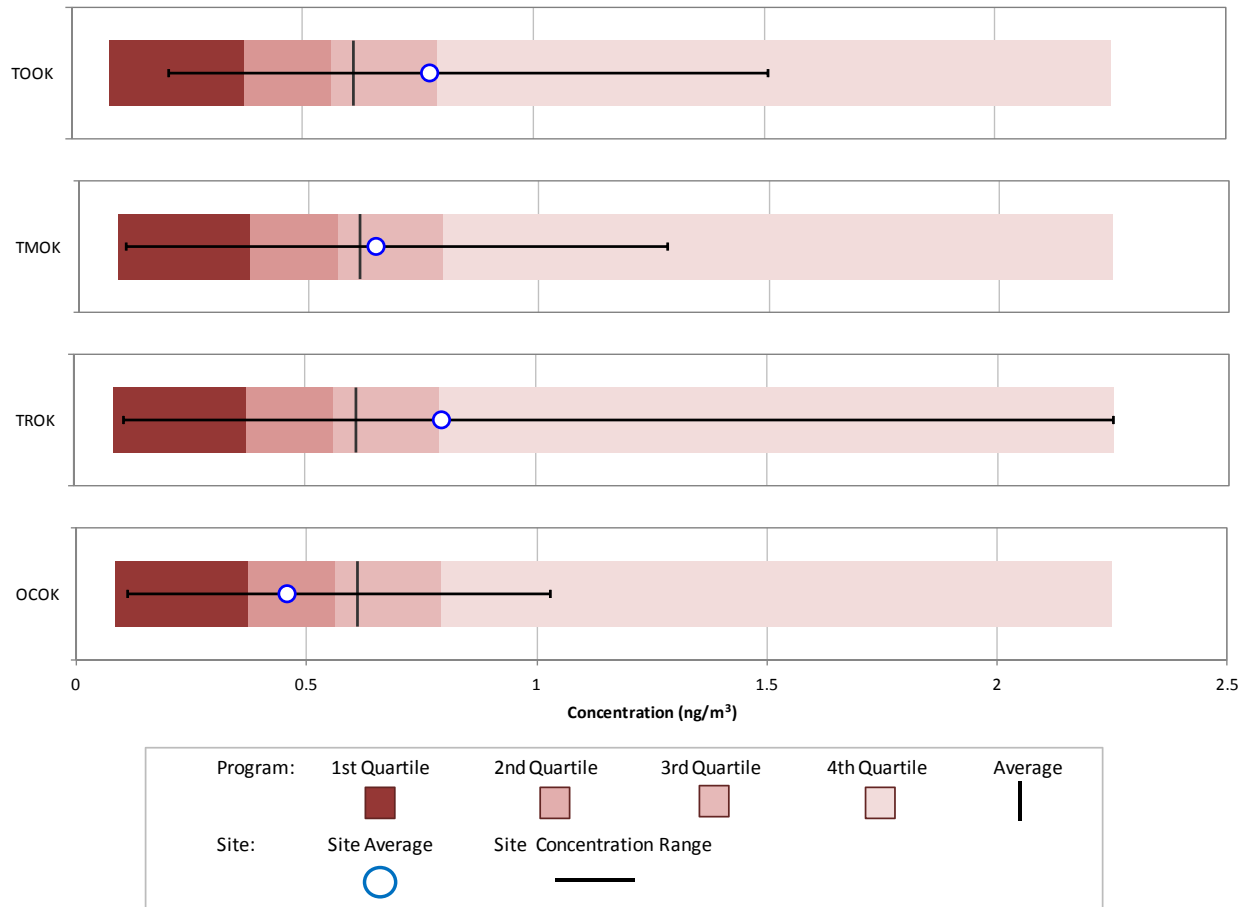
In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 22-4 for the three Tulsa sites and OCOK. Figures 22-15 through 22-26 overlay these sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1. Figures 22-15 through 22-26 and their associated observations are as follows:

Figure 22-15. Program vs. Site-Specific Average Acetaldehyde Concentrations



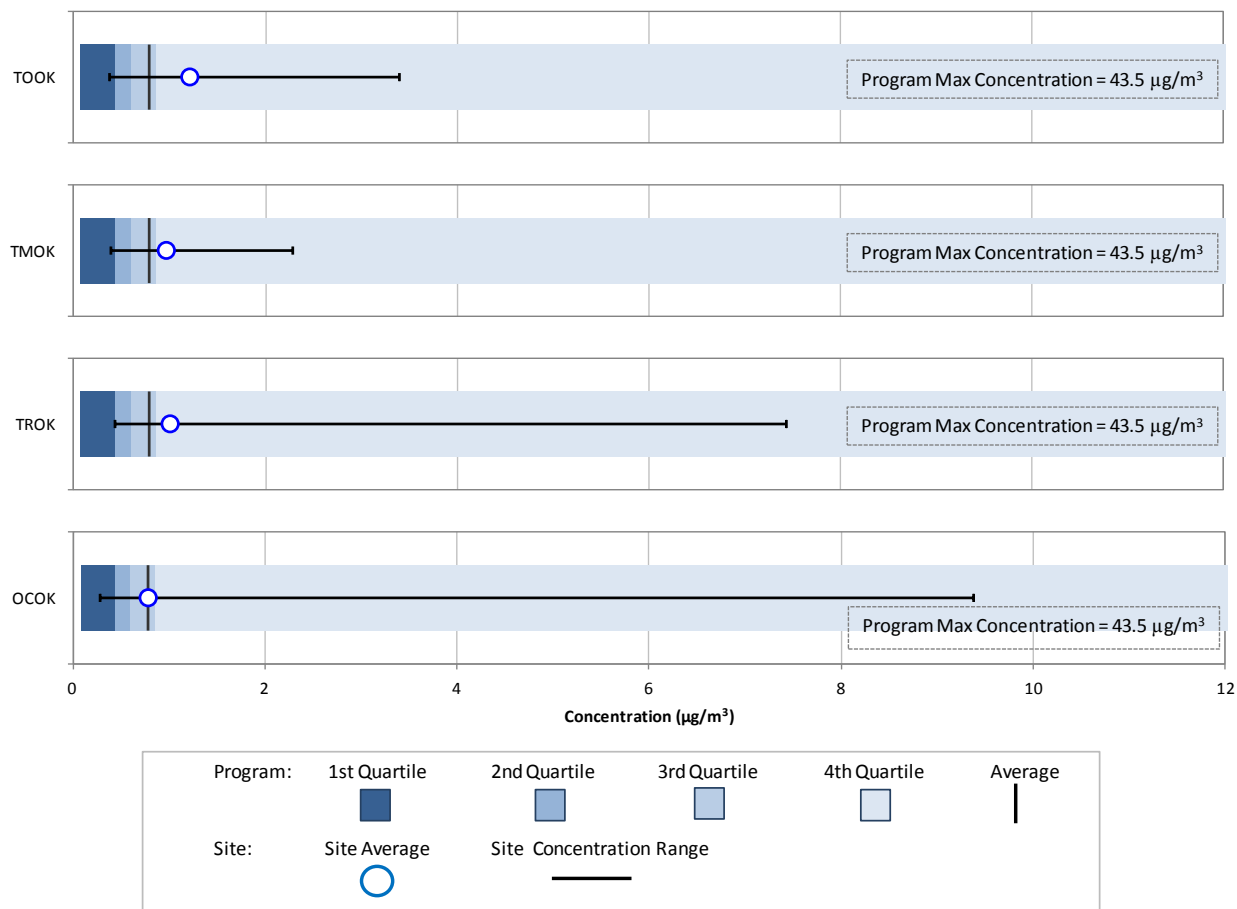
- Figure 22-15 presents the box plots for acetaldehyde for the Tulsa sites and OCOK. The range of acetaldehyde concentrations measured at TOOK was similar to the range measured at TMOK, while the range of concentrations measured at TROK and OCOK were slightly smaller. The annual average concentrations for these four sites fall between the program-level second and third quartiles, with the annual averages for TOOK, TMOK, and OCOK slightly greater than the program-level average concentration and the annual average for TROK slightly less than the program-level average.

Figure 22-16. Program vs. Site-Specific Average Arsenic (TSP) Concentrations



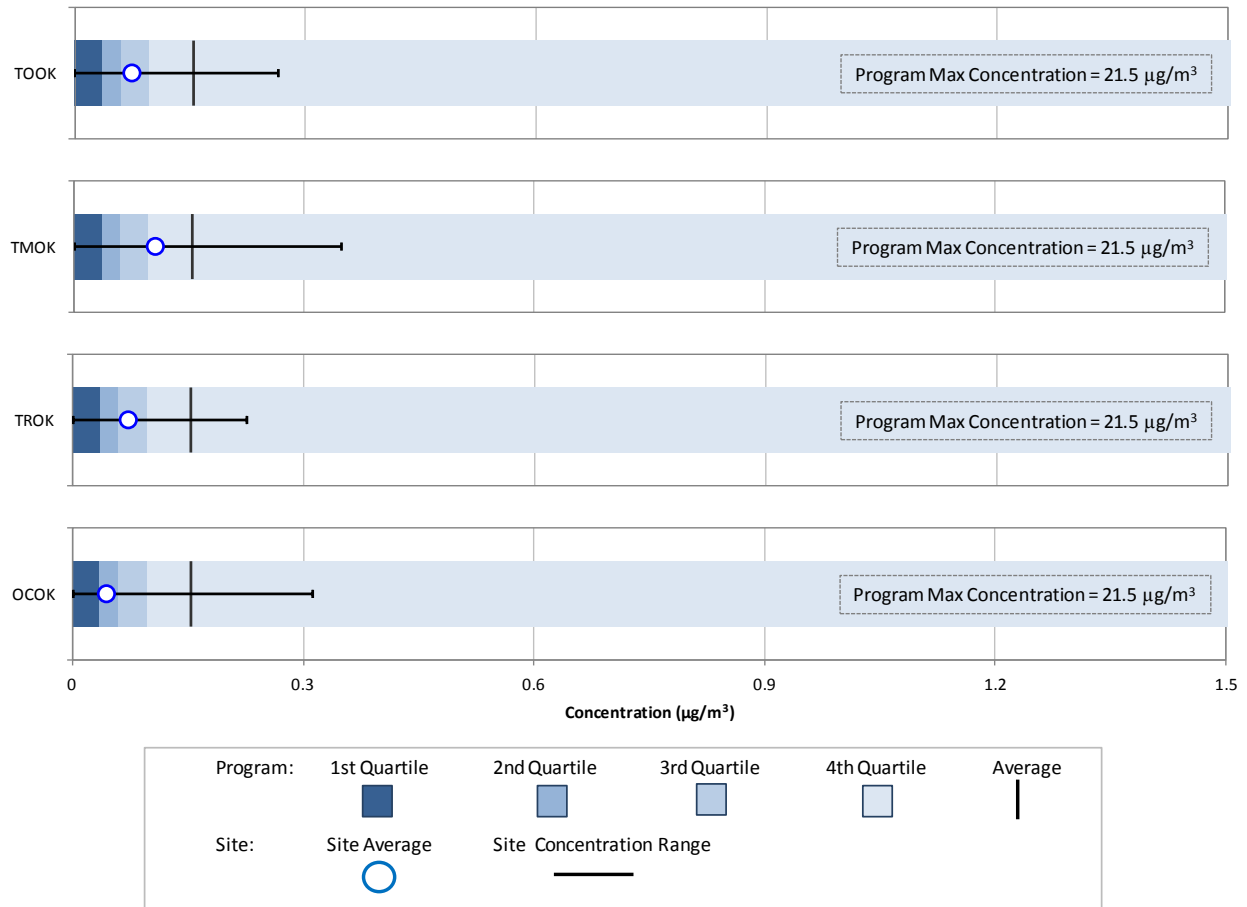
- Because the Oklahoma sites are the only sites sampling TSP metals, Figure 22-16 compares the individual Oklahoma site arsenic data against the combined Oklahoma data. Figure 22-16 shows that the maximum arsenic concentration among the Oklahoma sites was measured at TROK. The annual average arsenic (TSP) concentration is greatest for TROK (although the annual average for TOOK is similar) and lowest for OCOK. This figure also shows that arsenic concentrations were higher at the Tulsa sites, based on the range of measurements as well as the annual average concentrations.

Figure 22-17. Program vs. Site-Specific Average Benzene Concentrations



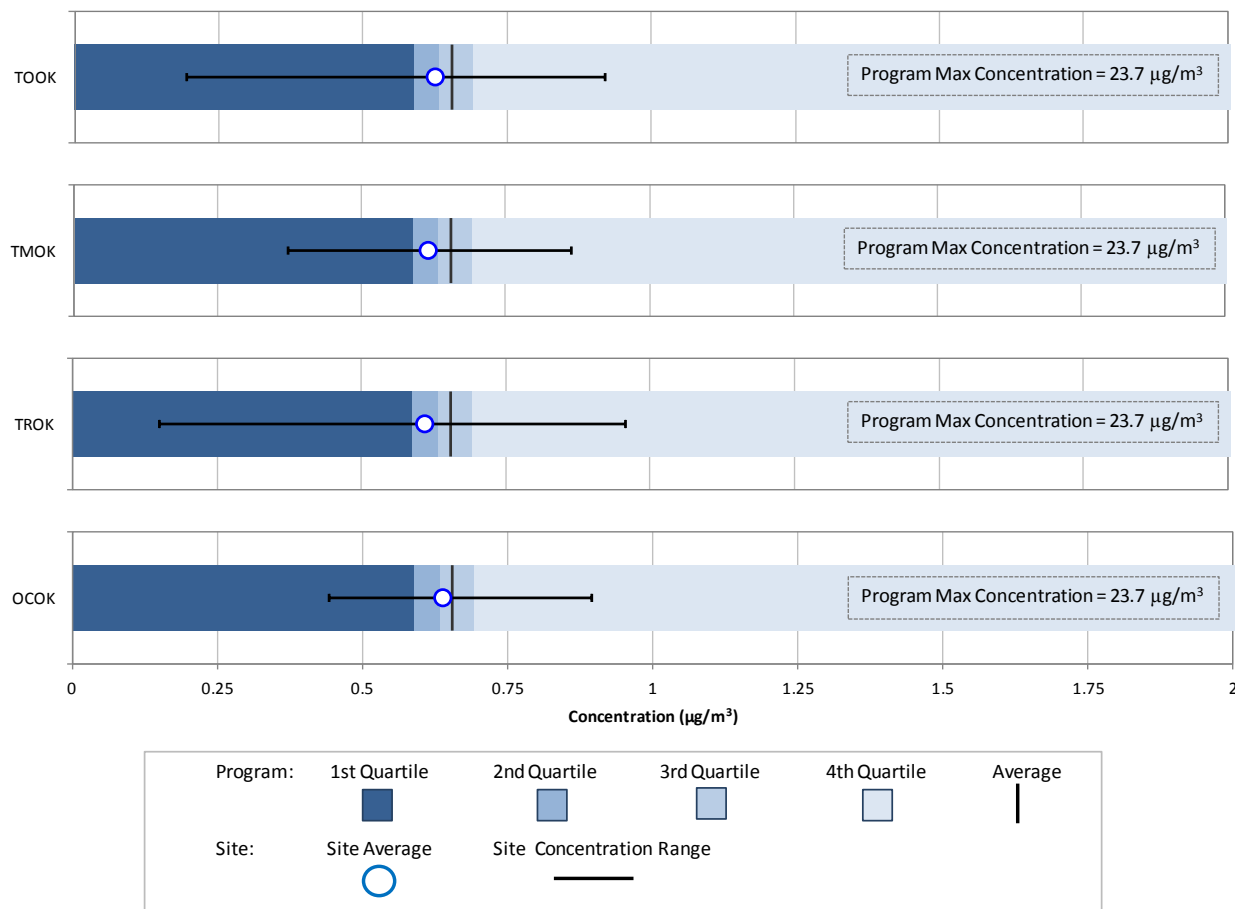
- Figure 22-17 presents the box plots for benzene. Note that the program-level maximum concentration ($43.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plots has been reduced to $12 \mu\text{g}/\text{m}^3$. The box plots show that the smallest range of benzene concentrations was measured at TMOK while the largest range was measured at OCOK. The maximum benzene concentration measured at OCOK is the second highest benzene concentration measured across the program, yet this site has the lowest annual average concentration of this pollutant compared to the other Oklahoma sites. The annual average concentrations of benzene for the Tulsa sites are greater than the program-level average concentration while the annual average for OCOK is similar to it. The minimum concentration measured at TROK is similar to the program-level first quartile concentration, while the minimum benzene concentrations measured at TMOK and TROK are just less than program-level first quartile.

Figure 22-18. Program vs. Site-Specific Average 1,3-Butadiene Concentrations



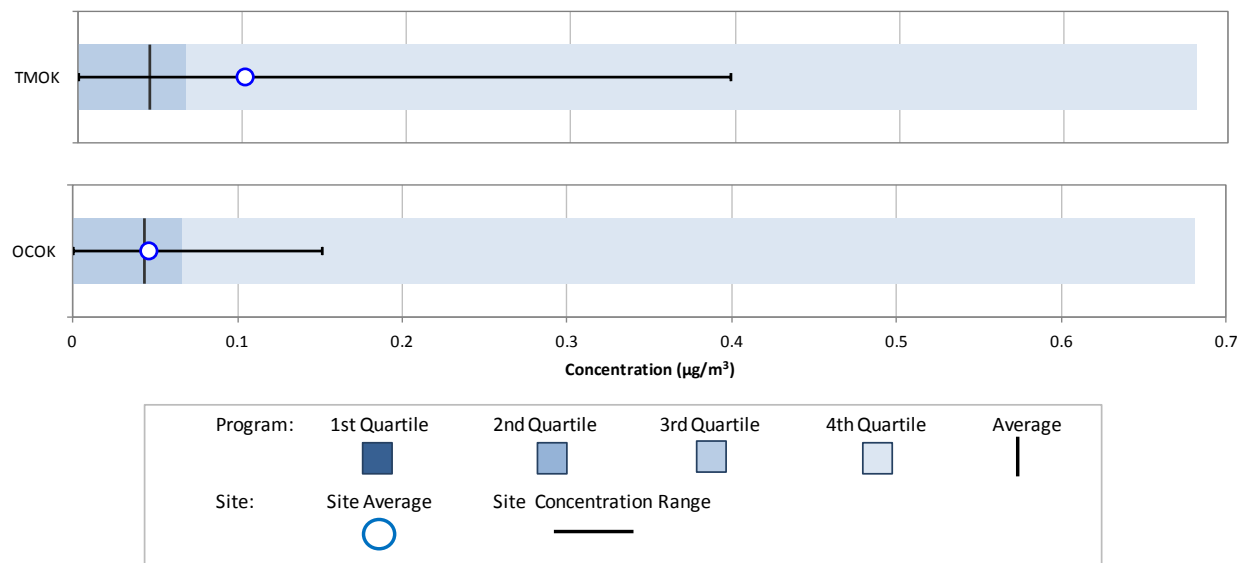
- Figure 22-18 presents the box plots for 1,3-butadiene. Note that the program-level maximum concentration ($21.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plots has been reduced to $1.5 \mu\text{g}/\text{m}^3$. Note that the program-level average concentration is greater than the program-level third quartile, indicating that the concentrations on the upper end of the range of measurements are driving the program-level average. All of the annual average concentrations of 1,3-butadiene for the Oklahoma sites are less than the program-level average concentration. The annual average concentration of 1,3-butadiene is highest for TMOK and lowest for OCOK, although the range of measurements is smallest for TROK.

Figure 22-19. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations



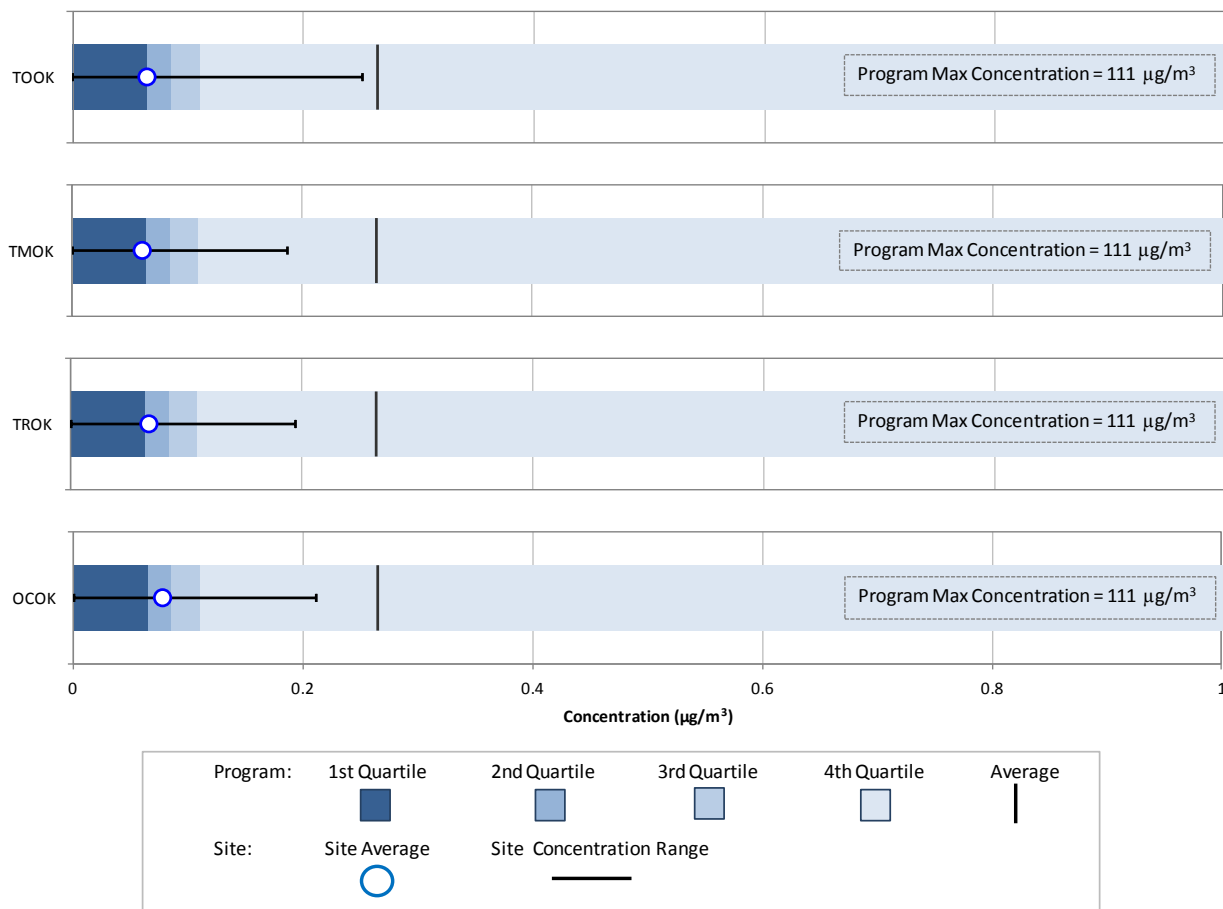
- Figure 22-19 presents the box plots for carbon tetrachloride. Similar to other VOCs, the program-level maximum concentration ($23.7 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots for carbon tetrachloride as the scale of the box plots has been reduced to $2 \mu\text{g}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. The range of carbon tetrachloride concentrations measured at each site was largest for TROK and smallest for OCOK. The annual average concentrations of carbon tetrachloride did not vary much across the Oklahoma sites, ranging between $0.60 \mu\text{g}/\text{m}^3$ and $0.65 \mu\text{g}/\text{m}^3$ for each site, all of which are just less than the program level average concentration of $0.66 \mu\text{g}/\text{m}^3$.

Figure 22-20. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentrations



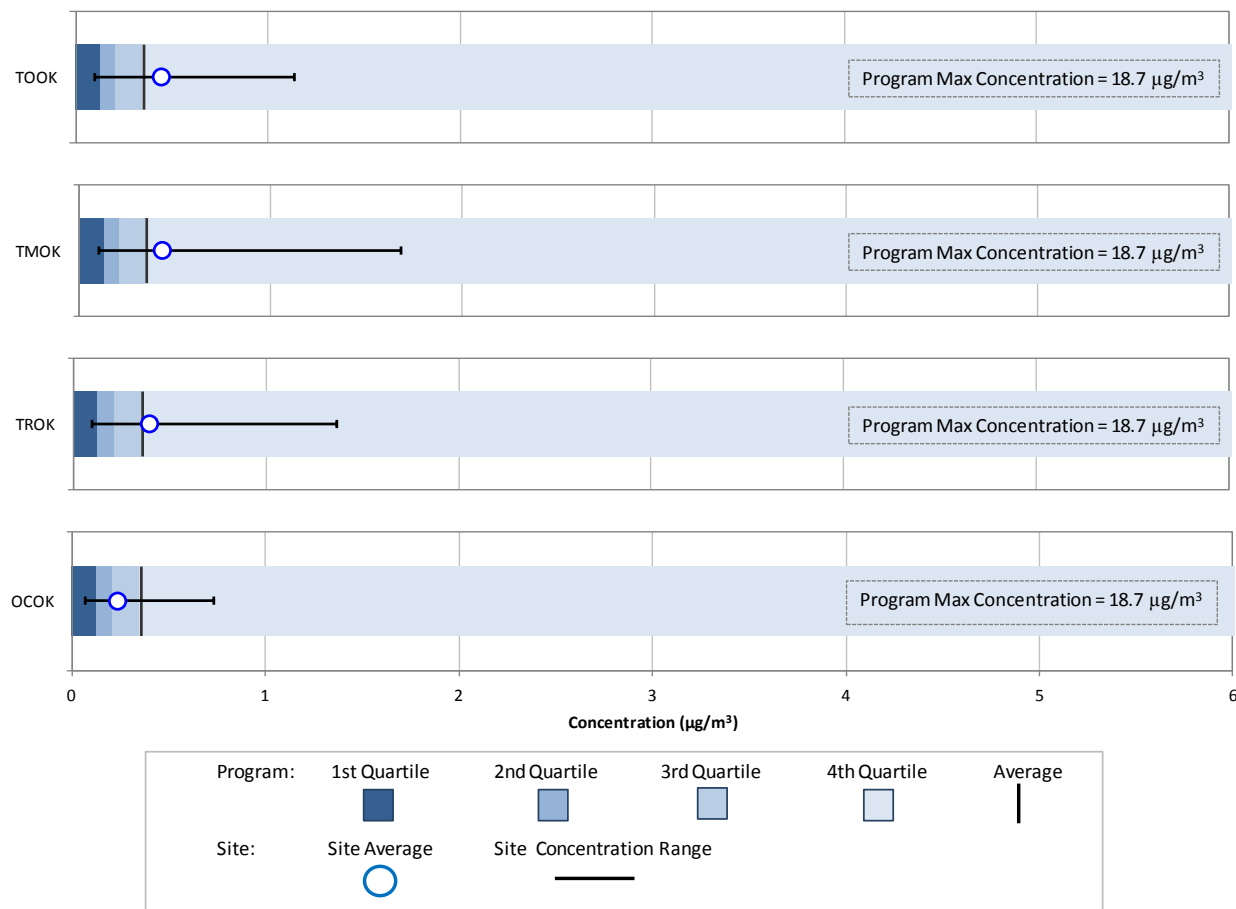
- Figure 22-20 presents the box plots for *p*-dichlorobenzene for TMOK and OCOK, the only Oklahoma sites for which this is a pollutant of interest. Note that the first and second quartiles are both zero for this pollutant, indicating that at least half of the measurements are non-detects and thus, are not visible on the box plots. The maximum concentration measured at TMOK is twice the maximum concentration measured at OCOK, although both are less than the maximum concentration measured across the program. The annual average *p*-dichlorobenzene concentration for TMOK is more than twice the program-level average concentration while the annual average for OCOK is similar to it. The number of non-detects measured at OCOK (22) is two and half times greater than the number measured at TMOK (9).

Figure 22-21. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations



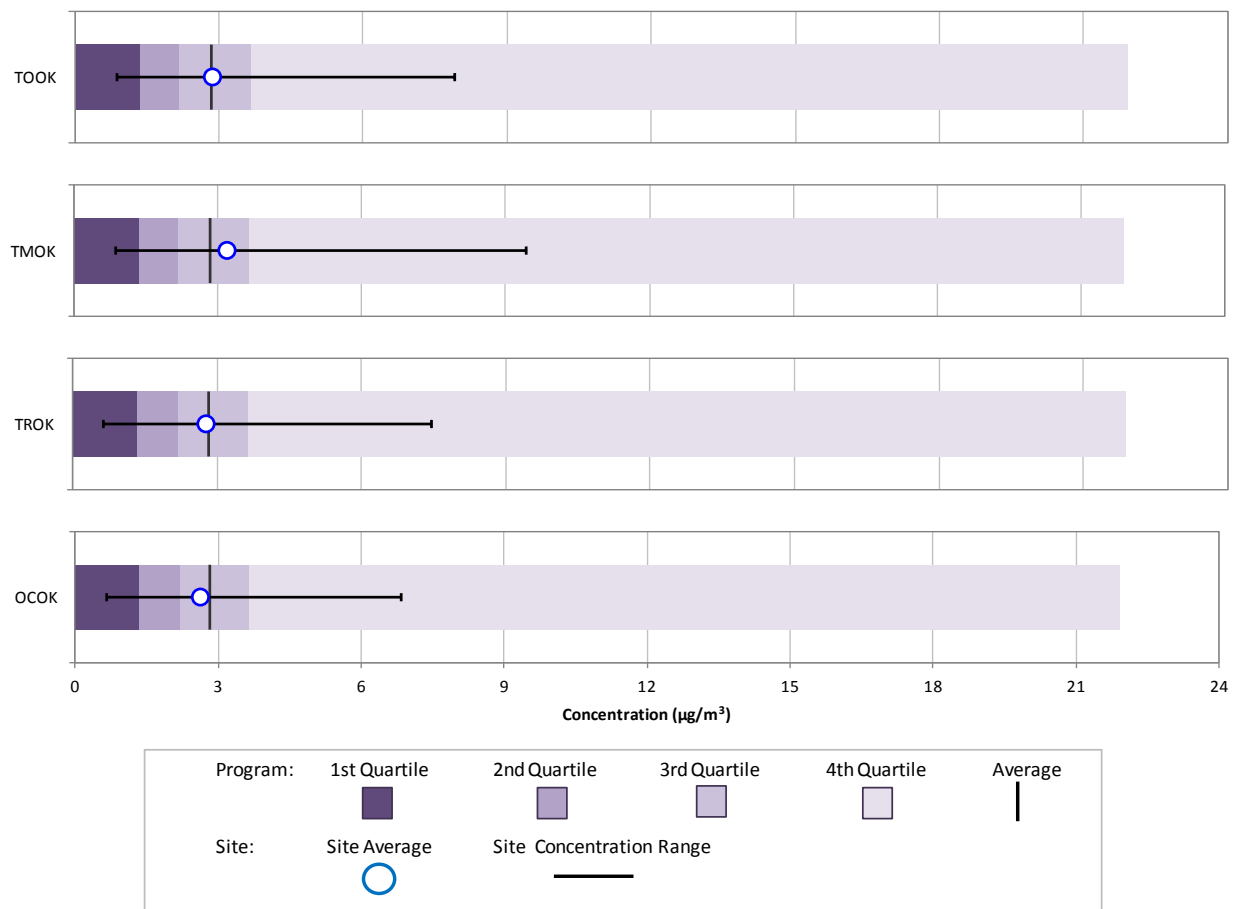
- Figure 22-21 presents the box plots for 1,2-dichloroethane. Similar to other VOCs, the program-level maximum concentration ($111 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots as the scale has been reduced to $1 \mu\text{g}/\text{m}^3$ to allow for the observation of data points at the lower end of the concentration range. The program-level average concentration is being driven by the higher measurements collected at a few monitoring sites. Figure 22-21 shows that the entire range of 1,2-dichloroethane concentrations measured at the Oklahoma sites are less than the average concentration across the program. The annual average concentrations of 1,2-dichloroethane for these sites are all less than the program-level median concentration, with the annual averages for the Tulsa sites similar to the program-level first quartile.

Figure 22-22. Program vs. Site-Specific Average Ethylbenzene Concentrations



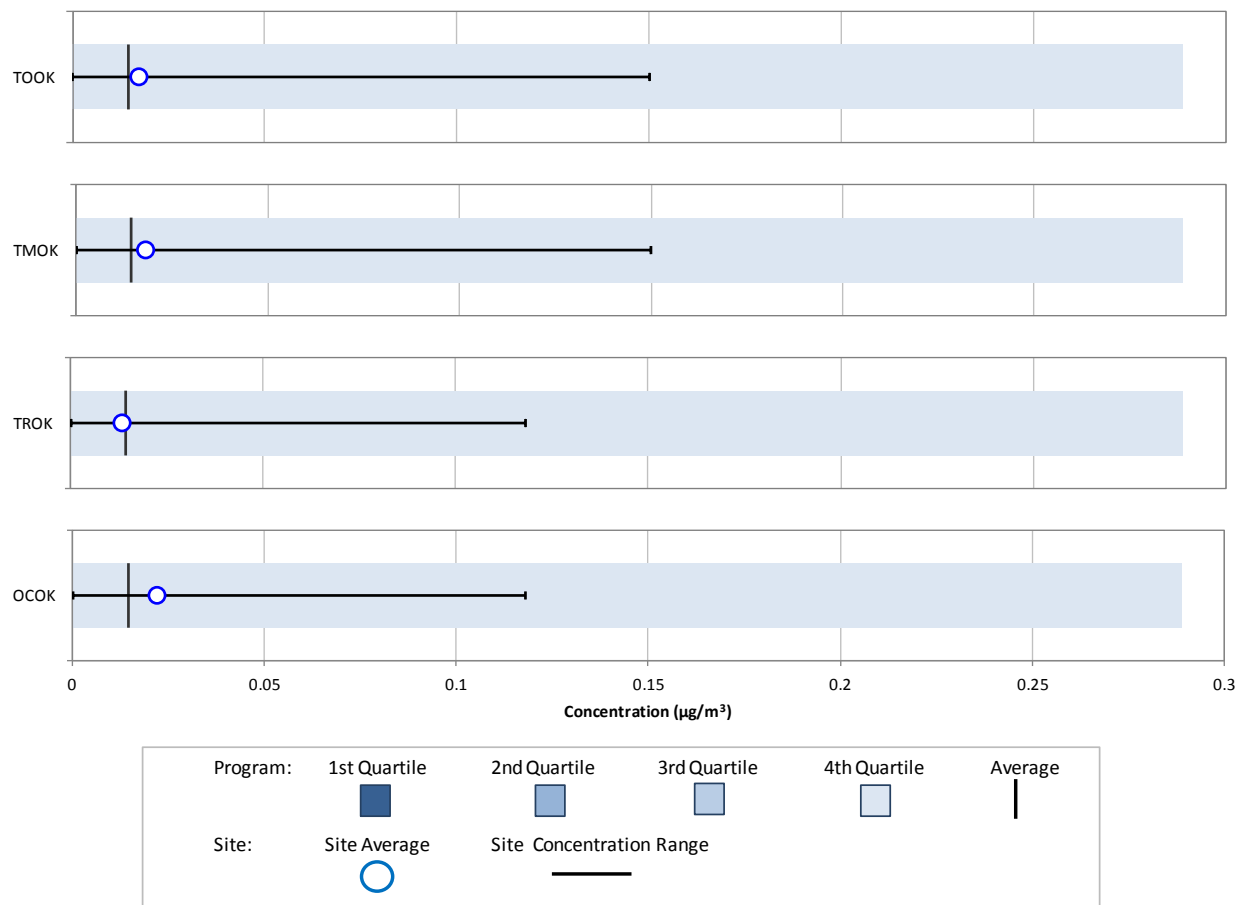
- Figure 22-22 presents the box plots for ethylbenzene. The scale of these box plots has also been reduced to allow for the observation of data points at the lower end of the concentration range. The range of ethylbenzene concentrations measured is largest for TMOK and smallest for OCOK. The annual average concentrations for the Tulsa sites are greater than the program-level average concentration while the annual average concentration for OCOK is closer to the program-level median concentration.

Figure 22-23. Program vs. Site-Specific Average Formaldehyde Concentrations



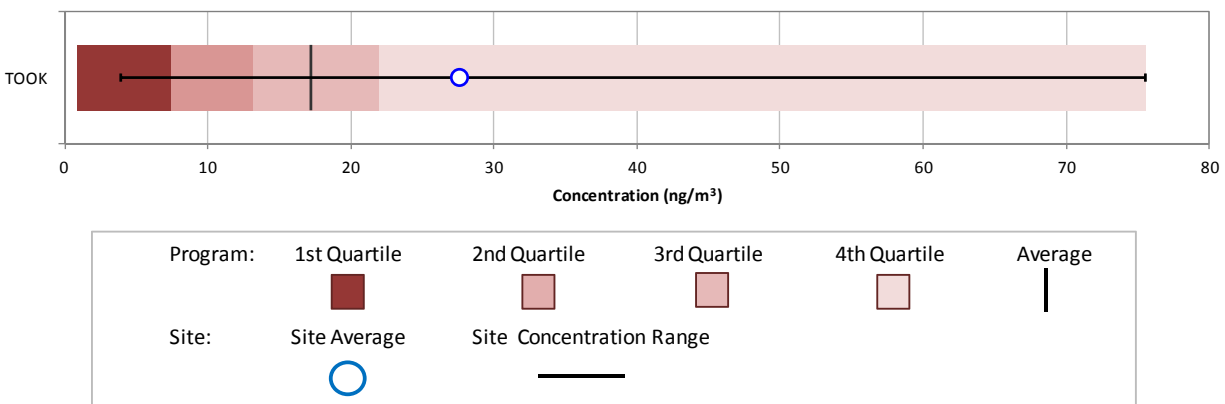
- Figure 22-23 presents the box plots for formaldehyde for the Tulsa sites and OCOK. The range of formaldehyde concentrations measured at these sites is in descending order from top to bottom in Figure 22-23, as are the annual average concentrations, which vary little from the program-level average concentrations.

Figure 22-24. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentrations



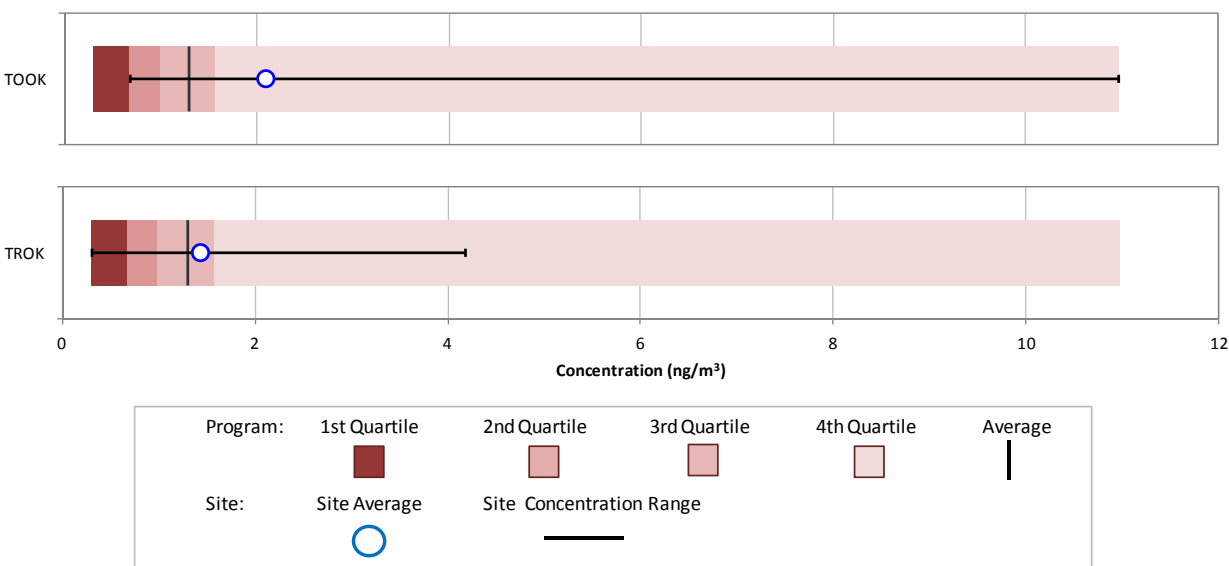
- Figure 22-24 presents the box plots for hexachloro-1,3-butadiene for the Oklahoma sites. Note that the first, second, and third quartiles for hexachloro-1,3-butadiene are zero at the program-level and therefore not visible on the box plots due to the large number of non-detects. For these sites, roughly one-quarter or less of the measurements of this pollutant were measured detections, although none were greater than the MDL. OCOK has the highest annual average hexachloro-1,3-butadiene concentration while TROK has the lowest, though less than $0.01 \mu\text{g}/\text{m}^3$ separates them.

Figure 22-25. Program vs. Site-Specific Average Manganese (TSP) Concentration



- Figure 22-25 presents the manganese data for TOOK, the only Oklahoma site for which manganese is a pollutant of interest. Because the Oklahoma sites are the only sites sampling TSP metals, Figure 22-25 compares the arsenic measurements collected at TOOK against the combined Oklahoma data. Figure 22-25 shows that the maximum manganese concentration among the Oklahoma sites was measured at TOOK. The annual average manganese concentration for TOOK is greater than the program-level manganese concentration and third quartile (TSP only).

Figure 22-26. Program vs. Site-Specific Average Nickel (TSP) Concentrations

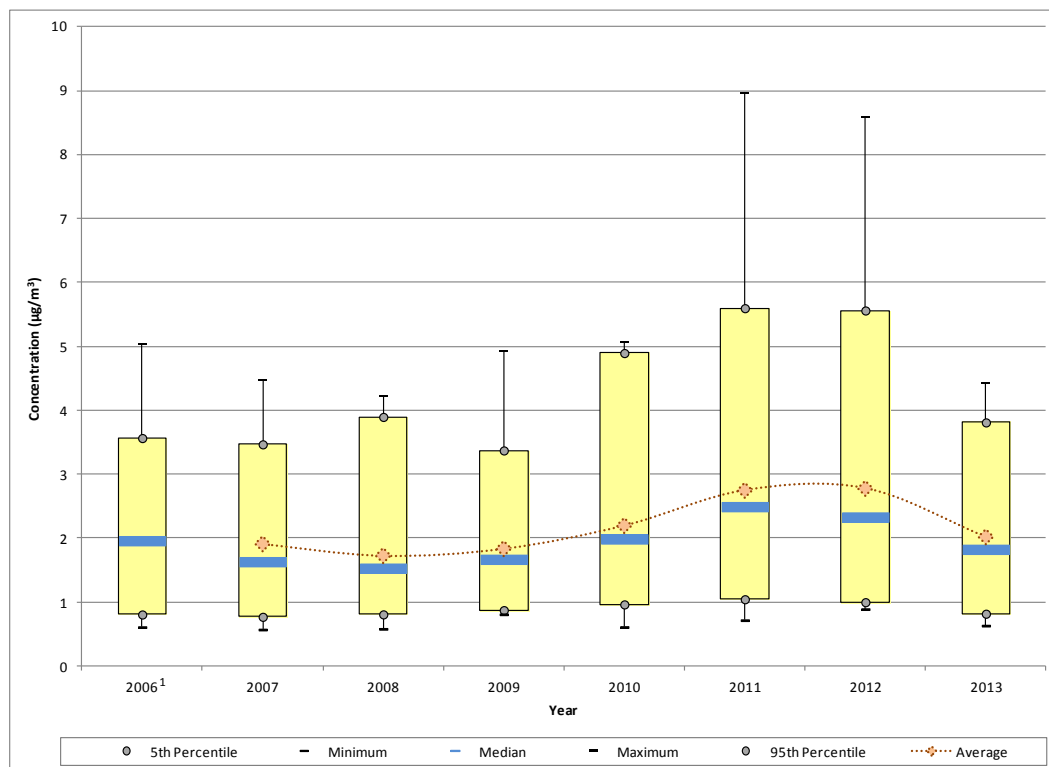


- Figure 22-26 presents the nickel concentration data for the two Oklahoma sites for which nickel was identified as a pollutant of interest. The maximum concentration of nickel among the Oklahoma sites was measured at TOOK while the minimum nickel concentration measured at TOOK is greater than the program-level first quartile (TSP only). The range of nickel measurements is greater for TOOK than TROK. The annual average nickel concentration for TOOK is nearly 50 percent higher than the annual average concentration for TROK.

22.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. TOOK has sampled TSP metals, carbonyl compounds, and VOCs under the NMP since 2006 and TMOK and OCOK have sampled these pollutants since 2009. Thus, Figures 22-27 through 22-57 present the 1-year statistical metrics for each of the pollutants of interest first for TOOK, followed by TMOK and OCOK. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 22-27. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at TOOK

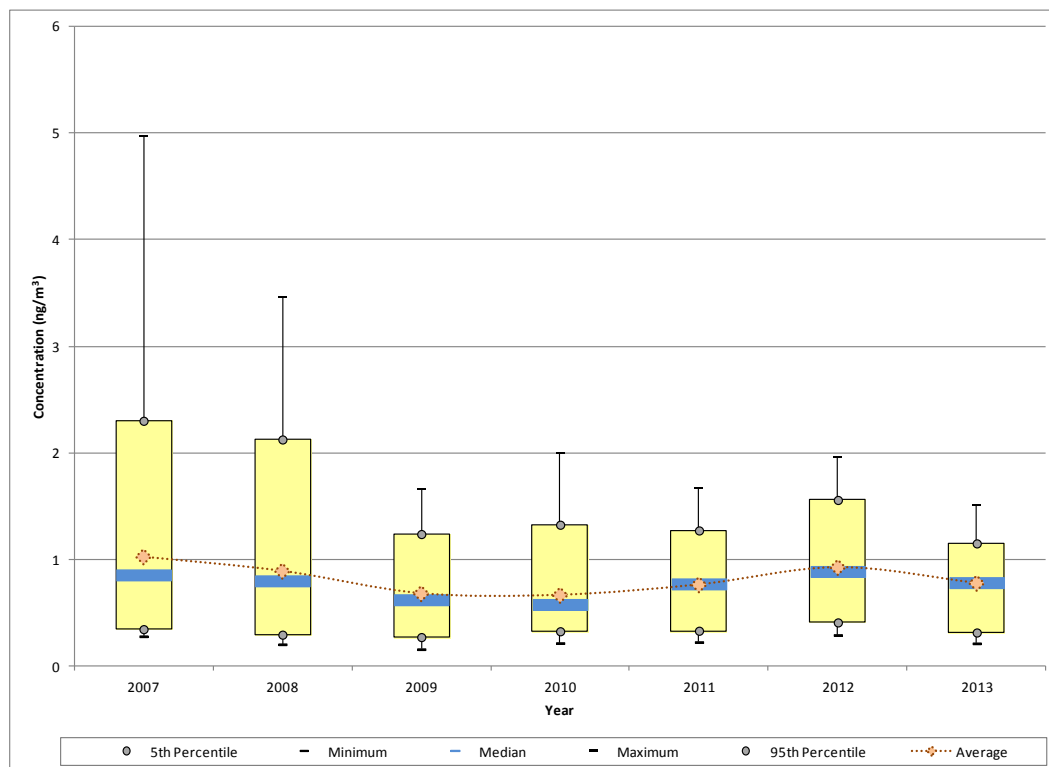


¹ A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 22-27 for acetaldehyde measurements collected at TOOK include the following:

- Although TOOK began sampling carbonyl compounds under the NMP in January 2006, equipment complications at the onset of sampling resulted in a low completeness for 2006; thus, a 1-year average concentration is not presented for 2006, although the range of measurements is provided.
- The maximum concentration of acetaldehyde was measured in 2011 (8.95 $\mu\text{g}/\text{m}^3$), although a similar concentration was also measured in 2012 (8.59 $\mu\text{g}/\text{m}^3$). The 12 highest concentrations were all measured in 2011 or 2012. Of the 33 acetaldehyde concentrations greater than 4 $\mu\text{g}/\text{m}^3$ measured at TOOK, 12 were measured in 2012, eight were measured in 2011, five were measured in 2010, and three or fewer were measured in all other years.
- The statistical metrics exhibit an increasing trend between 2009 and 2011. The 95th percentiles for 2011 and 2012 are greater than the maximum concentrations measured prior to 2011.
- Little change is shown in the acetaldehyde measurements from 2011 to 2012 while a significant decrease in acetaldehyde concentrations is shown for 2013.

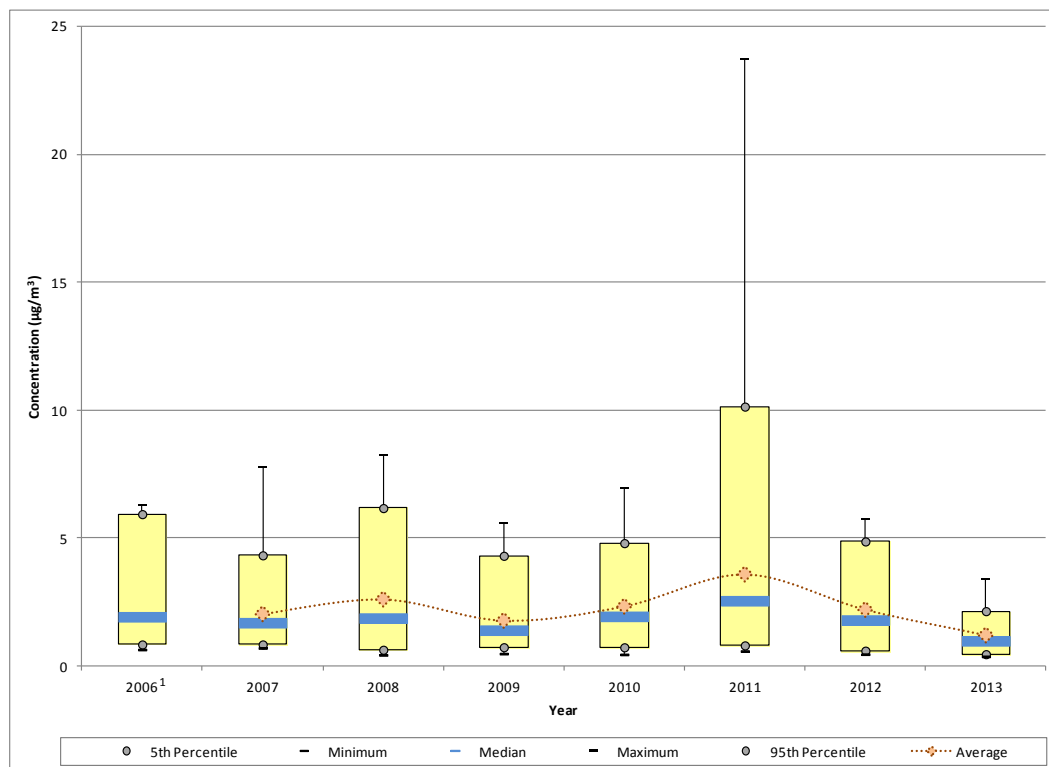
Figure 22-28. Yearly Statistical Metrics for Arsenic (TSP) Concentrations Measured at TOOK



Observations from Figure 22-28 for arsenic (TSP) measurements collected at TOOK include the following:

- Although TOOK began sampling TSP metals in 2006, sampling did not begin until October, which does not yield enough samples for the statistical metrics to be calculated; thus, Figure 22-28 excludes data from 2006 per the criteria specified in Section 3.4.3.2.
- The two highest concentrations of arsenic were measured at TOOK in September 2007 and are the only two concentrations greater than 4 ng/m³ measured at TOOK. All eight concentrations of arsenic greater than 2 ng/m³ were measured in either 2007 or 2008.
- The 1-year average and median concentrations exhibit a decreasing trend between 2007 and 2010, although the difference is relatively small between 2009 and 2010. The 1-year average and median concentrations increased for 2011, an increase that continued into 2012.
- The smallest range of arsenic concentrations was measured at TOOK in 2013. The difference between the 1-year average and median concentrations is at a minimum for 2013. Both of these indicate a decreasing level of variability in the arsenic measurements collected in 2013. All of the statistical parameters exhibit decreases from 2012 to 2013.

Figure 22-29. Yearly Statistical Metrics for Benzene Concentrations Measured at TOOK

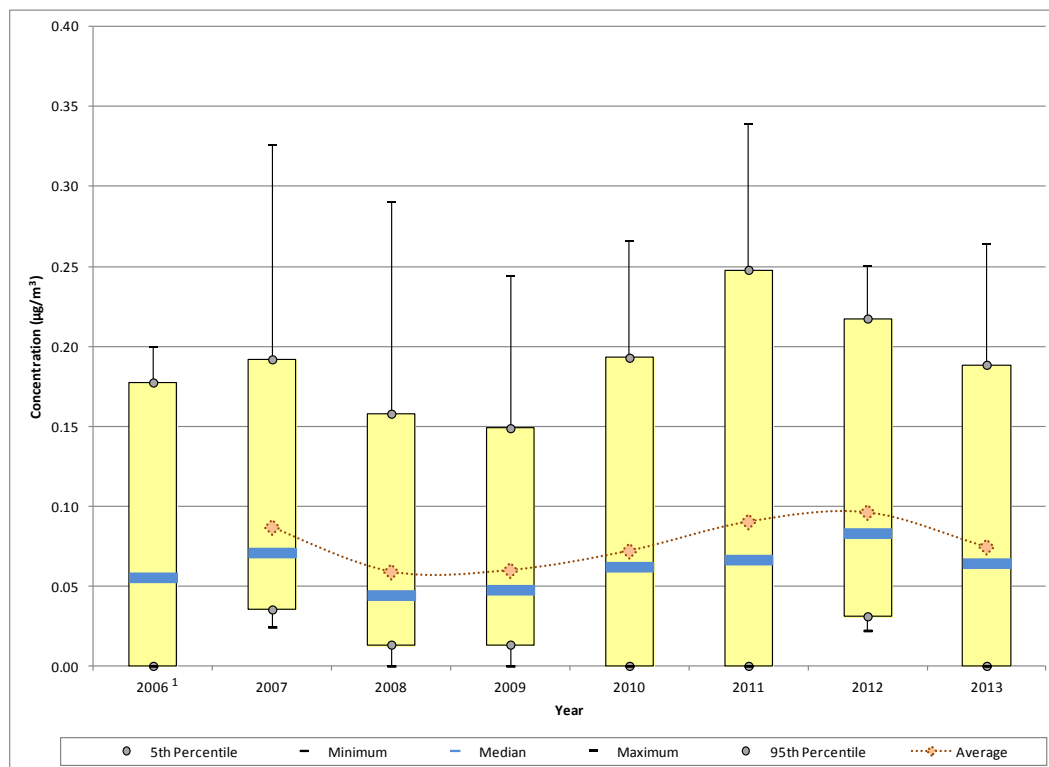


¹ A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 22-29 for benzene measurements collected at TOOK include the following:

- Although TOOK began sampling VOCs under the NMP in January 2006, equipment complications at the onset of sampling resulted in a low completeness for 2006; thus, a 1-year average concentration is not presented for 2006, although the range of measurements is provided.
- The maximum concentration of benzene was measured in 2011 ($23.8 \mu\text{g}/\text{m}^3$). All four of the benzene concentrations greater than $10 \mu\text{g}/\text{m}^3$ measured at TOOK were measured in 2011. The 95th percentile for 2011 is greater than the maximum concentration for each of the other years shown.
- The 1-year average benzene concentration has fluctuated over the years. After a significant decrease from 2008 to 2009, an increasing trend through 2011 occurred. After 2011, a significant decrease in benzene concentrations is exhibited, particularly for 2013. All of the statistical parameters are at a minimum for 2013. The maximum concentration measured in 2013 is less than the 95th percentiles for all previous years and is less than the 1-year average concentration for 2011.

Figure 22-30. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at TOOK

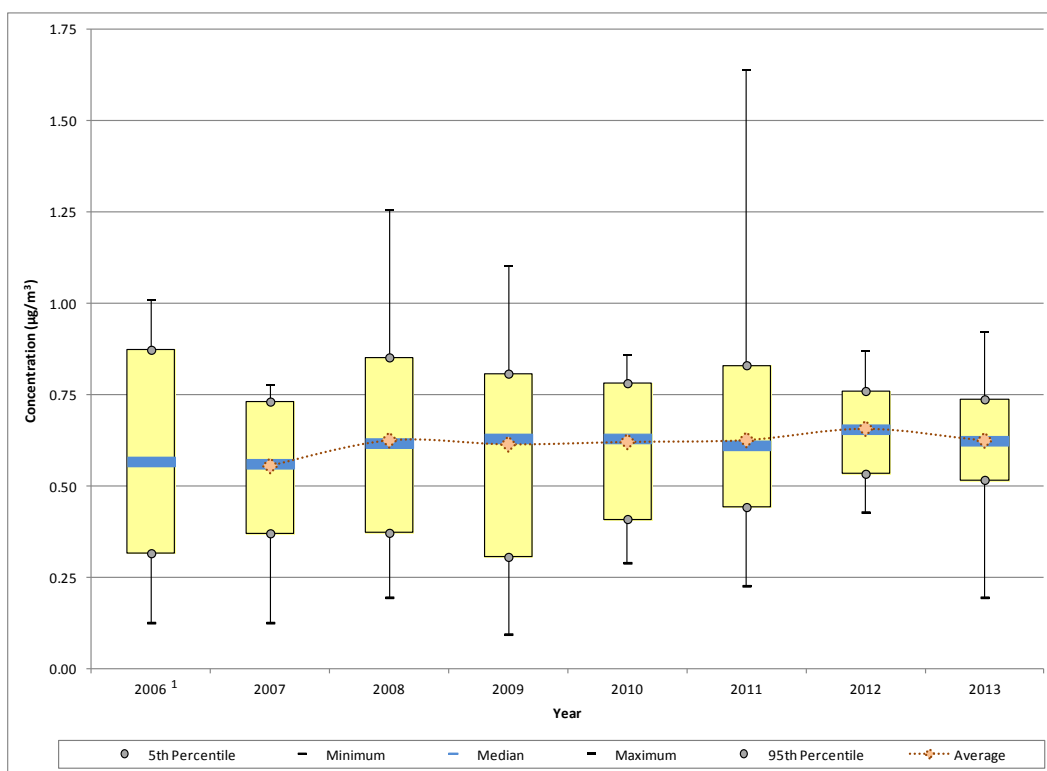


¹ A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 22-30 for 1,3-butadiene measurements collected at TOOK include the following:

- The maximum concentration of 1,3-butadiene was measured in December 2011 ($0.34 \mu\text{g}/\text{m}^3$), although a similar concentration was also measured in 2007 ($0.33 \mu\text{g}/\text{m}^3$). No other 1,3-butadiene concentrations greater than $0.3 \mu\text{g}/\text{m}^3$ have been measured at TOOK.
- After an initial decrease from 2007 to 2008 and little change for 2009, the 1-year average concentration began to increase, with the greatest increase occurring from 2010 to 2011. Even though the maximum and 95th percentile decreased, additional increases are shown for the 1-year average and median concentrations for 2012.
- With the exception of the maximum concentration, all of the statistical parameters exhibit decreases for 2013.
- The minimum concentration for most years is zero, indicating the presence of non-detects. For 2006, 2010, 2011, and 2013, both the minimum concentration and 5th percentile are zero, indicating that more than one non-detect was measured during those years. The percentage of non-detects has ranged from zero (2007 and 2012) to 14 percent (2006).

Figure 22-31. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at TOOK



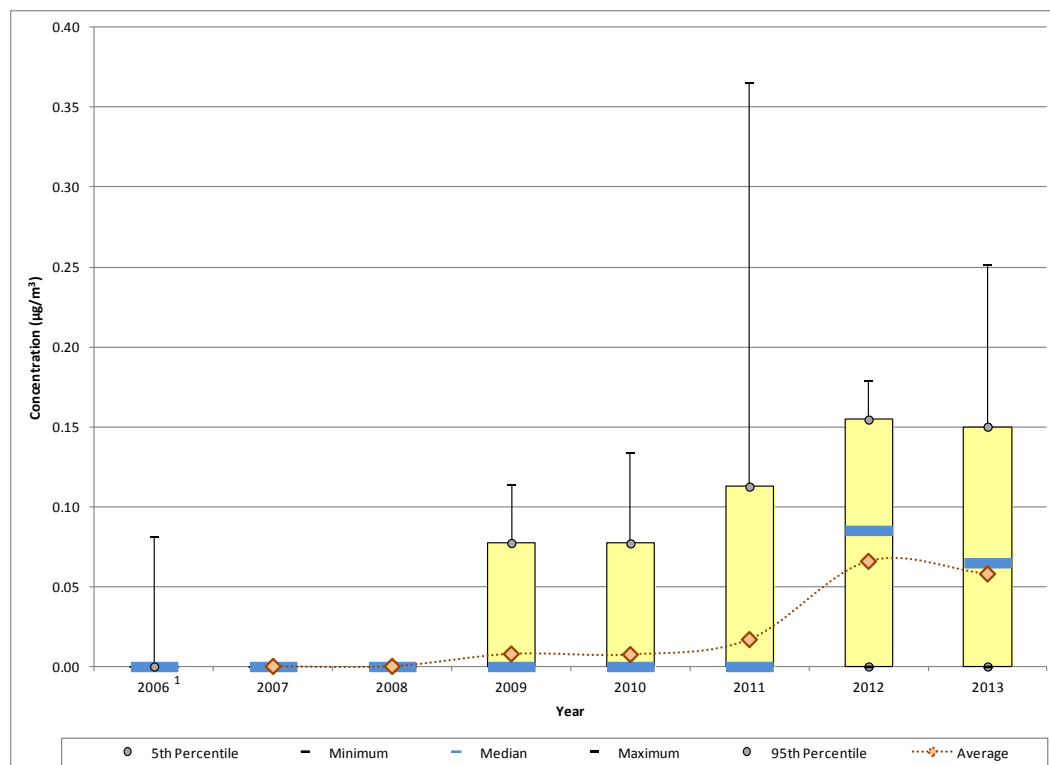
¹ A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 22-31 for carbon tetrachloride measurements collected at TOOK include the following:

- Similar to other compounds, the maximum concentration of carbon tetrachloride was measured in 2011 ($1.64 \mu\text{g}/\text{m}^3$). Four additional concentrations greater than $1 \mu\text{g}/\text{m}^3$ have been measured at TOOK.
- With the exception of 2011, the range of carbon tetrachloride measurements spans roughly $1 \mu\text{g}/\text{m}^3$ or less. The range of measurements is at a minimum for 2012, when the difference between the minimum and maximum concentrations is less than $0.45 \mu\text{g}/\text{m}^3$.
- The 1-year average concentration increased slightly from 2007 to 2008, after which little change is shown through 2011. Between 2008 and 2011, the 1-year average concentrations range from $0.61 \mu\text{g}/\text{m}^3$ to $0.63 \mu\text{g}/\text{m}^3$. A slight increase is shown for 2012 ($0.66 \mu\text{g}/\text{m}^3$), even though the measurements for this year exhibit the least variability. For 2013, the majority of concentrations fall into a similar range as 2012, although the range of concentrations measured widened. Across the years of sampling, the 1-year average concentration of carbon tetrachloride has varied by only $0.10 \mu\text{g}/\text{m}^3$.

- For each year shown, the 1-year average concentration is very similar to the median concentration. The difference between these two parameters is greatest for 2009, yet only $0.02 \mu\text{g}/\text{m}^3$ separates them. This indicates that there is relatively little variability in the central tendency of these measurements.

Figure 22-32. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at TOOK



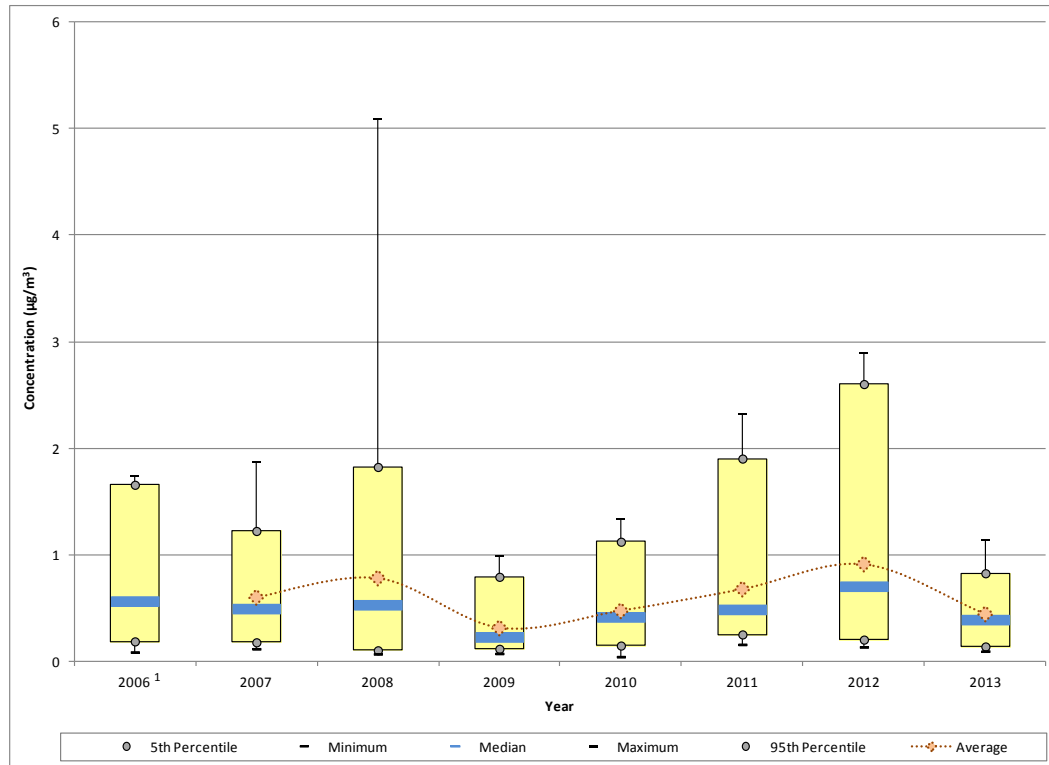
¹ A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 22-32 for 1,2-dichloroethane measurements collected at TOOK include the following:

- The median concentration for all years through 2011 is zero, indicating that at least half of the measurements were non-detects. In 2006, there was one measured detection of 1,2-dichloroethane. In 2007 and 2008 there were none. Between 2009 and 2011, the number of measured detections varied from five to six. The number of measured detections increased significantly for 2012, up from six in 2011 to 38 in 2012. Greater than 30 measured detections were measured in 2013 as well.
- The 1-year average concentration for 2012 is less than the median concentration, which is a little unusual. The 1-year average concentration is more susceptible to outliers (on either end of the concentration range) than the median concentration, which represents the midpoint of a group of measurements. The 1-year average concentration for 2012 is less than the median, indicating that concentrations on the lower end of the concentration range (the many zeroes representing non-detects) are

pulling the average down (just like a maximum or outlier concentration can drive the average upward). This is also true for 2013, although the difference between the two statistical parameters is less.

Figure 22-33. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at TOOK



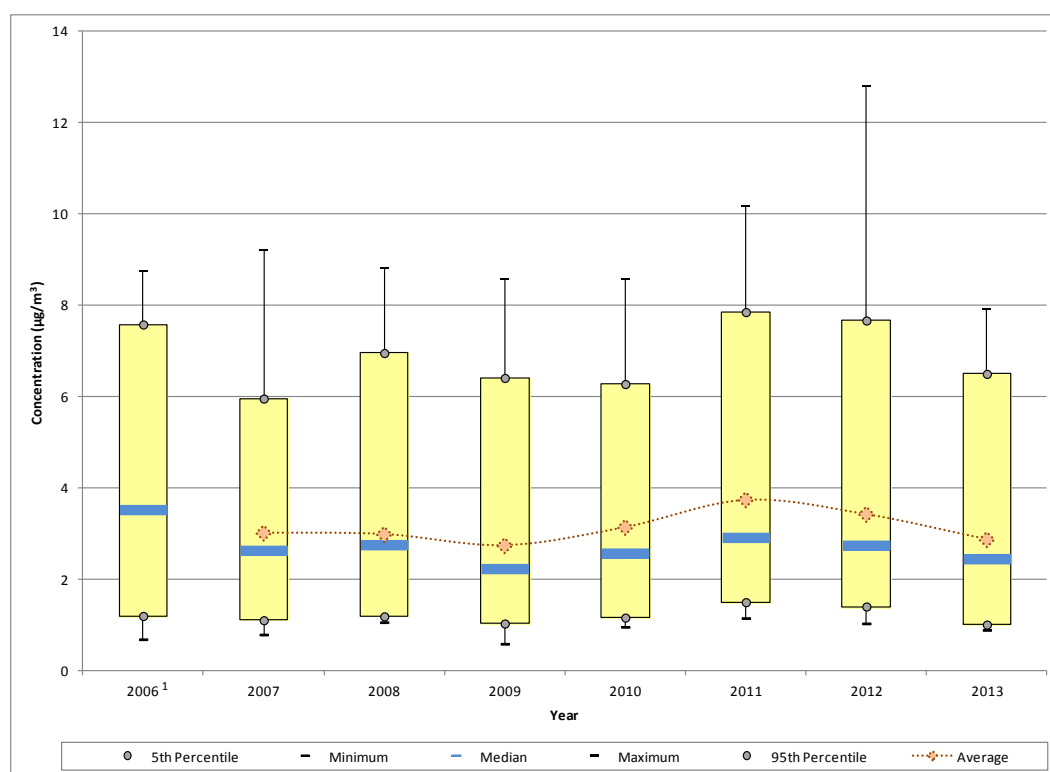
¹ A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 22-33 for ethylbenzene measurements collected at TOOK include the following:

- The two highest concentrations of ethylbenzene were both measured during the summer of 2008 (5.09 µg/m³ and 4.57 µg/m³). No other ethylbenzene concentrations greater than 3 µg/m³ have been measured at TOOK since the onset of sampling. The next five highest concentrations, those between 2.50 µg/m³ and 3 µg/m³, were all measured at TOOK in 2012.
- The maximum, 95th percentile, and 1-year average concentrations exhibit increases from 2007 to 2008; even the median increased, although slightly. Even if the two highest concentrations measured in 2008 were excluded from the dataset, the 1-year average concentration would still exhibit a slight increase. The number of ethylbenzene concentrations greater than 1 µg/m³ nearly doubled from 2007 (seven) to 2008 (13).

- Most of the statistical parameters are at a minimum for 2009. The 1-year average and median concentrations decreased by more than half from 2008 to 2009. There were no ethylbenzene concentrations greater than $1 \mu\text{g}/\text{m}^3$ measured at TOOK in 2009.
- After 2009, concentrations of ethylbenzene measured at TOOK exhibit a significant increasing trend through 2012. The 95th percentile, 1-year average concentration, and the median concentration are all at a maximum for 2012. The 95th percentile for 2012 is greater than the maximum concentration for all other years except 2008. The 1-year average concentration for 2012 is approaching $1 \mu\text{g}/\text{m}^3$.
- Ethylbenzene concentrations measured in 2013 decreased significantly from 2012, as the 1-year average concentration decreased by more than half.

Figure 22-34. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at TOOK



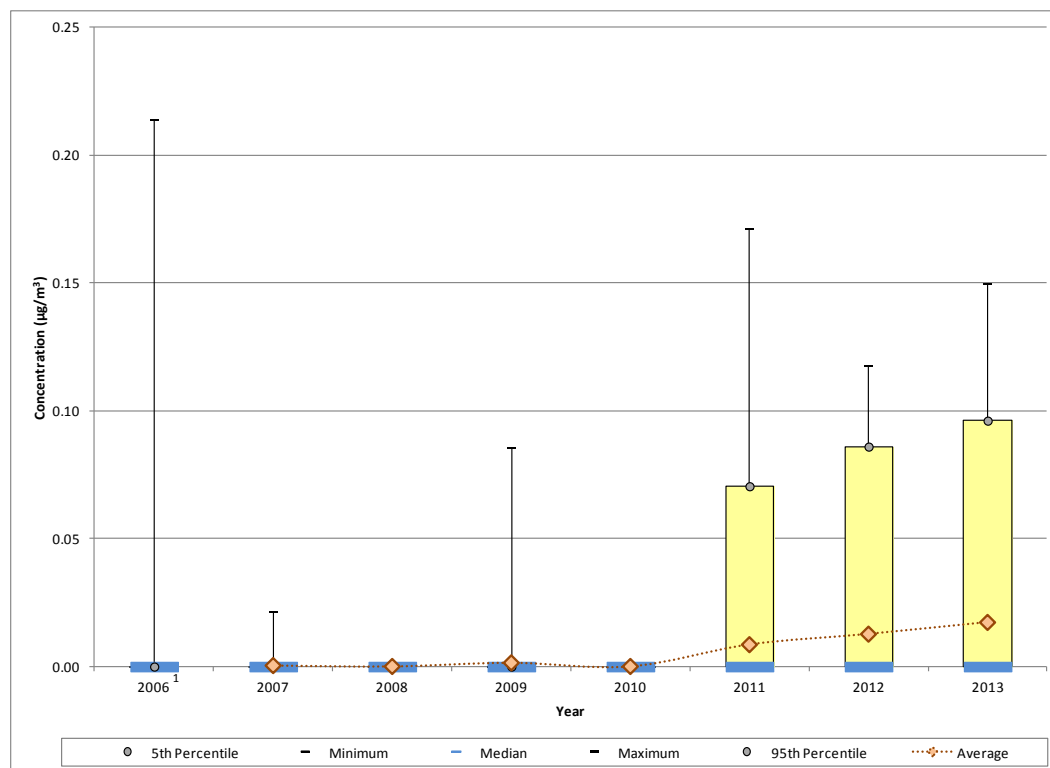
¹ A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 22-34 for formaldehyde measurements collected at TOOK include the following:

- The maximum concentration of formaldehyde ($12.80 \mu\text{g}/\text{m}^3$) was measured at TOOK on June 26, 2012. Only one other measurement greater than $10 \mu\text{g}/\text{m}^3$ has been measured at TOOK ($10.2 \mu\text{g}/\text{m}^3$ measured in 2011).
- All but two of the 79 formaldehyde concentrations greater than $5 \mu\text{g}/\text{m}^3$ were measured during the period between May and September, regardless of year.

- Similar to acetaldehyde, an increasing trend in the 1-year average concentration is shown for formaldehyde between 2009 and 2011. The 1-year average increased by $1 \mu\text{g}/\text{m}^3$ over this period.
- Even though the maximum formaldehyde concentration was measured in 2012, all of the other statistical parameters exhibit slight decreases. Further decreases are shown for all of the statistical parameters for 2013.

Figure 22-35. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at TOOK

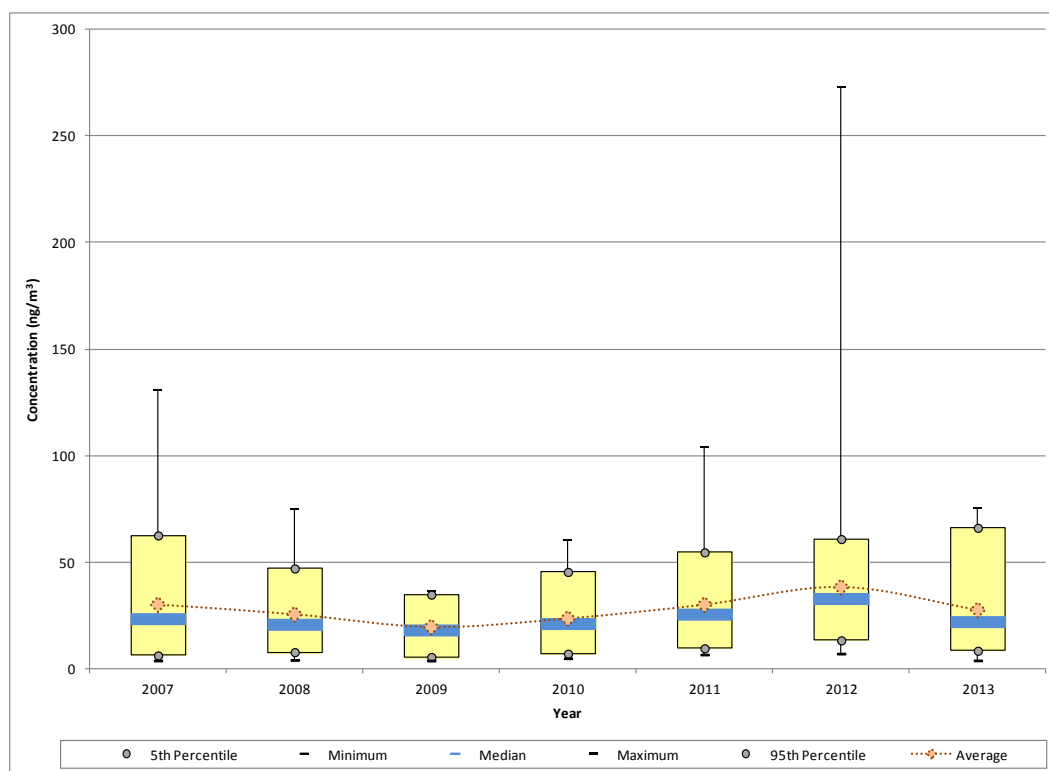


¹ A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 22-35 for hexachloro-1,3-butadiene measurements collected at TOOK include the following:

- The trends graphs for hexachloro-1,3-butadiene resembles the trends graph for 1,2-dichloroethane in that there were few measured detections in the first several years of sampling at TOOK.
- The median concentration is zero for all years of sampling, indicating that at least half of the measurements were non-detects for each year. Between 2006 and 2010, there were a total of four measured detections. In 2011, five measured detections were reported. This number doubled for 2012 and is at a maximum for 2013 (13).

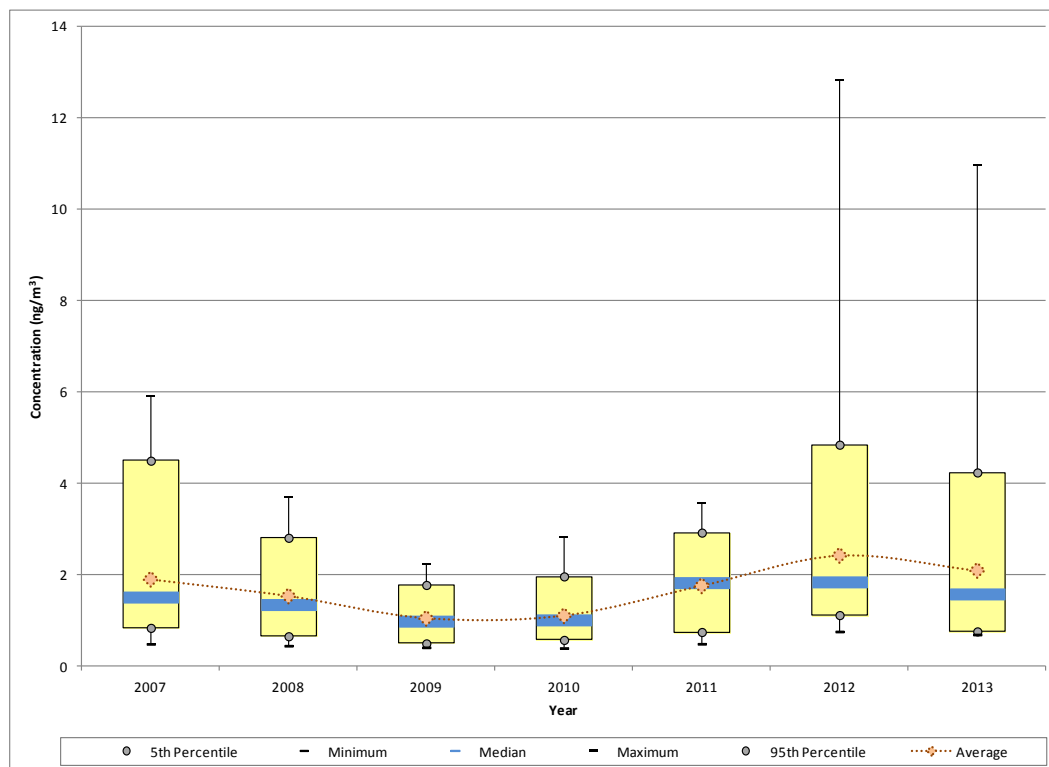
Figure 22-36. Yearly Statistical Metrics for Manganese (TSP) Concentrations Measured at TOOK



Observations from Figure 22-36 for manganese (TSP) measurements collected at TOOK include the following:

- The maximum concentration of manganese was measured in 2012 (273 ng/m³), on the day of a dust storm (October 18, 2012). Measurements greater than 100 ng/m³ were also measured in 2007 (131 ng/m³) and 2011 (104 ng/m³).
- A decreasing trend in the concentrations is shown through 2009, which was followed by an increasing trend through 2012. Even if the maximum concentration measured in 2012 was excluded from the calculations, the 1-year average and median concentrations would still exhibit an increasing trend for 2012. This is because there were more concentrations at the upper end of the concentration range for 2012 (the number of manganese measurements greater than 50 ng/m³ increased from five in 2011 to 12 in 2012) as well as fewer concentrations at the lower end of the concentration range (the number of manganese measurements less than 20 ng/m³ decreased from 17 in 2011 to 11 in 2012).

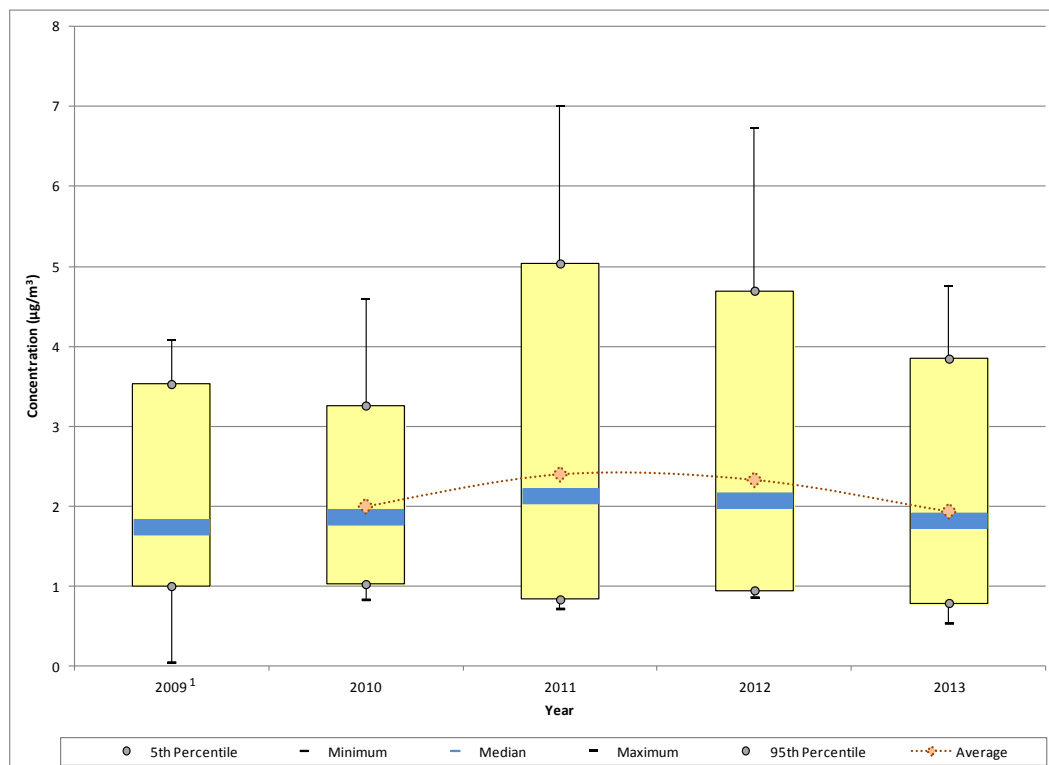
Figure 22-37. Yearly Statistical Metrics for Nickel (TSP) Concentrations Measured at TOOK



Observations from Figure 22-37 for nickel (TSP) measurements collected at TOOK include the following:

- The trends graph for nickel resembles the trends graph for manganese in several ways.
- The maximum concentration of nickel was measured at TOOK on the same day as the maximum concentration of manganese (October 18, 2012, the day of a dust storm). Only two nickel concentrations greater than 10 ng/m³ have been measured at TOOK, with the other on July 3, 2013 (11.0 ng/m³). Six of the eight nickel concentrations greater than 5 ng/m³ were measured at TOOK in either 2012 or 2013 (with the other two in 2007).
- A significant decreasing trend in the nickel concentrations measured at TOOK is shown through 2009. A slight increase is shown for 2010, which was followed by significant increases for 2011 and 2012. The minimum concentration shown for 2012 is greater than the 5th percentile for the four previous years.
- All of the statistical parameters exhibit slight decreases for 2013.

Figure 22-38. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at TMOK

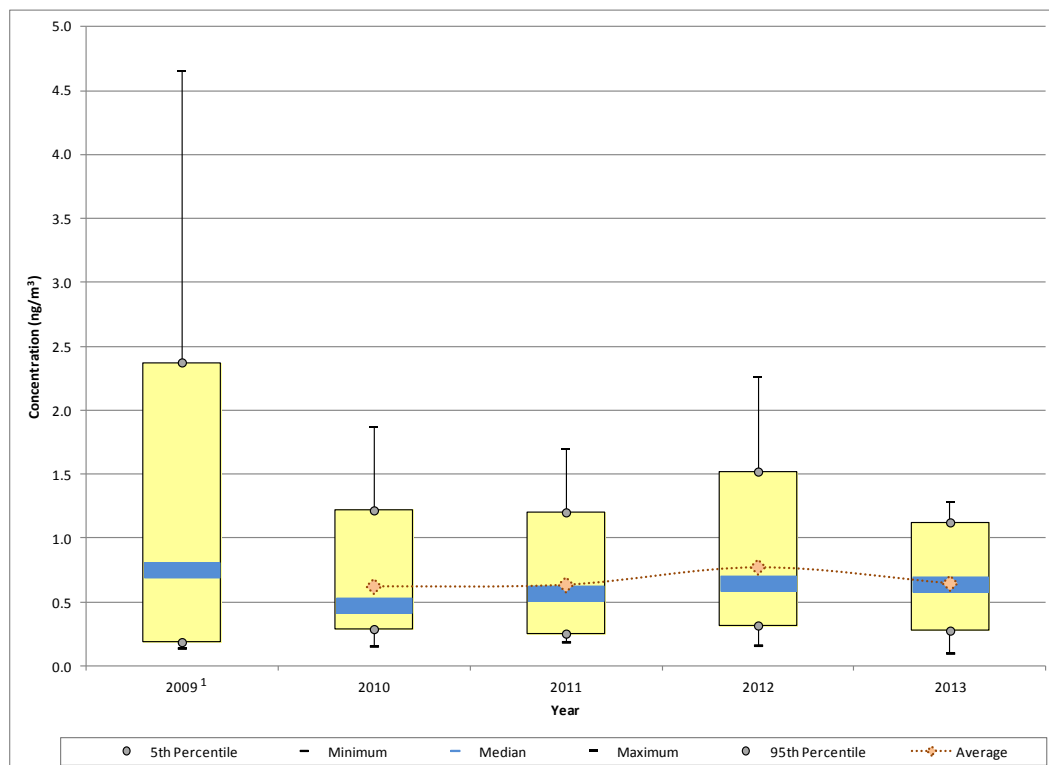


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2009.

Observations from Figure 22-38 for acetaldehyde measurements collected at TMOK include the following:

- Sampling for carbonyl compounds began at TMOK under the NMP in April 2009. A 1-year average concentration is not presented for 2009 because a full year's worth of data is not available, although the range of measurements is provided.
- The maximum acetaldehyde concentration ($7.00 \mu\text{g}/\text{m}^3$) was measured at TMOK on August 19, 2011. All seven acetaldehyde concentrations greater than $5 \mu\text{g}/\text{m}^3$ were measured in either 2011 or 2012.
- The range of acetaldehyde concentrations measured increased considerably from 2010 to 2011, after which the range of measurements has decreased each year. Although a decreasing trend is shown in the 1-year average and median concentrations between 2011 and 2013, the difference is not statistically significant.

Figure 22-39. Yearly Statistical Metrics for Arsenic (TSP) Concentrations Measured at TMOK

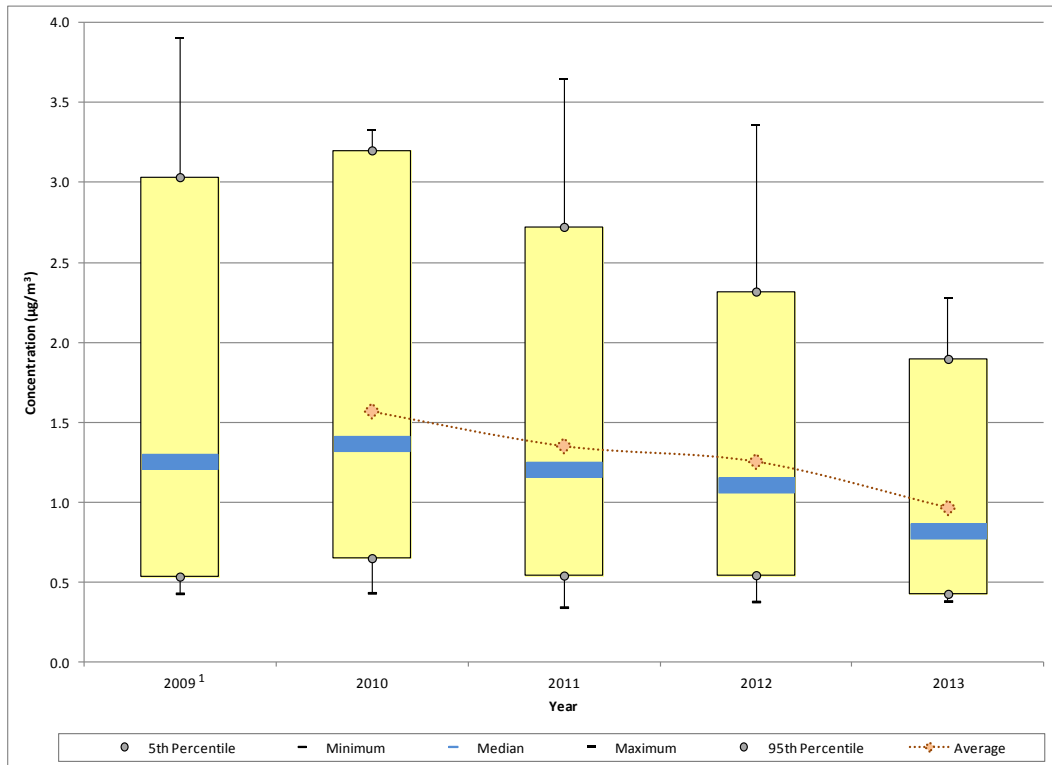


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2009.

Observations from Figure 22-39 for arsenic (TSP) measurements collected at TMOK include the following:

- Sampling for TSP metals began at TMOK under the NMP in April 2009. A 1-year average concentration is not presented for 2009 because a full year's worth of data is not available, although the range of measurements is provided.
- The three highest arsenic concentrations measured at TMOK were all measured in 2009 and all but one of the six arsenic concentrations greater than 2 ng/m³ were measured in 2009. The entire range of concentrations measured in other years is less than the 95th percentile for 2009 and the median concentration is at a maximum for 2009.
- Although a slight increasing trend is shown between 2010 and 2012, the changes in the 1-year average concentrations are not statistically significant.
- The smallest range of arsenic concentrations was measured in 2013. The difference between the 1-year average and median concentrations is at a minimum for 2013, as less than 0.01 ng/m³ separates them. Both of these indicate a decreasing level of variability in the arsenic measurements for 2013. A similar observation was made for TOOK.

Figure 22-40. Yearly Statistical Metrics for Benzene Concentrations Measured at TMOK

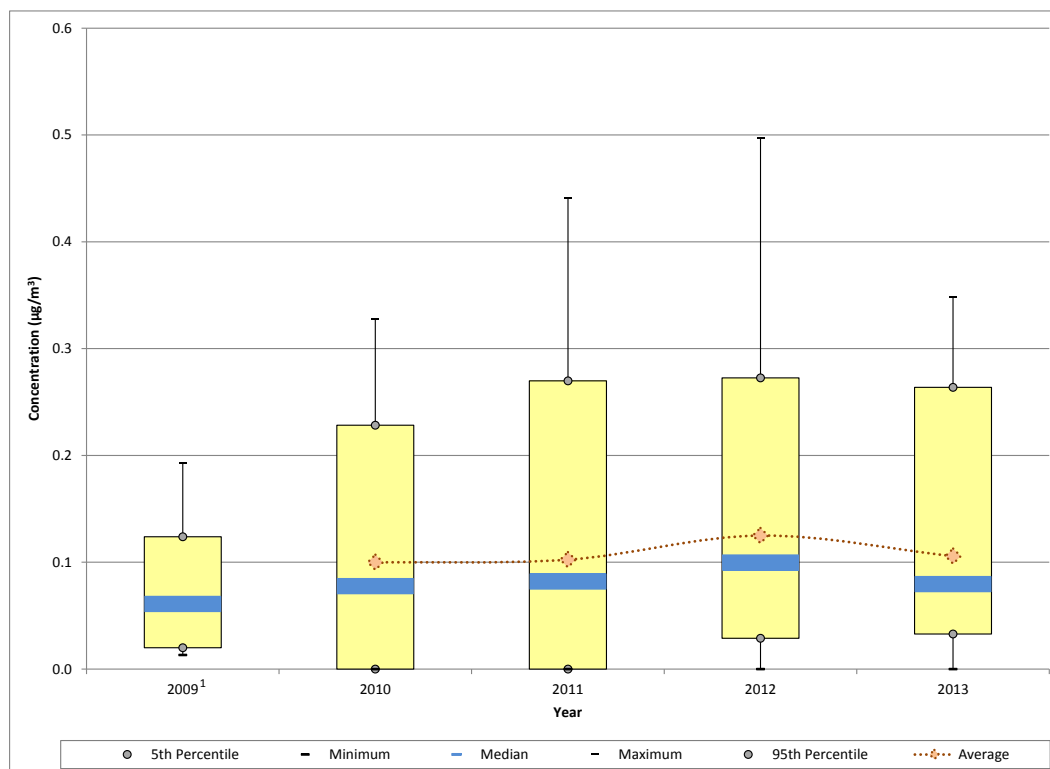


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2009.

Observations from Figure 22-40 for benzene measurements collected at TMOK include the following:

- Sampling for VOCs began at TMOK under the NMP in April 2009. A 1-year average concentration is not presented for 2009 because a full year's worth of data is not available, although the range of measurements is provided.
- The maximum benzene concentration ($3.91 \mu\text{g}/\text{m}^3$) was measured at TMOK on May 7, 2009, although benzene concentrations greater than $3 \mu\text{g}/\text{m}^3$ have been measured in all years of sampling except 2013.
- The 1-year average and median benzene concentrations have a significant decreasing trend between 2010 and 2013, with the largest decrease shown for 2013. The 1-year average and median concentrations have both decreased by more than $0.5 \mu\text{g}/\text{m}^3$ since the onset of sampling. The maximum concentration measured in 2013 is less than the 95th percentile for all the previous years of sampling.

Figure 22-41. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at TMOK

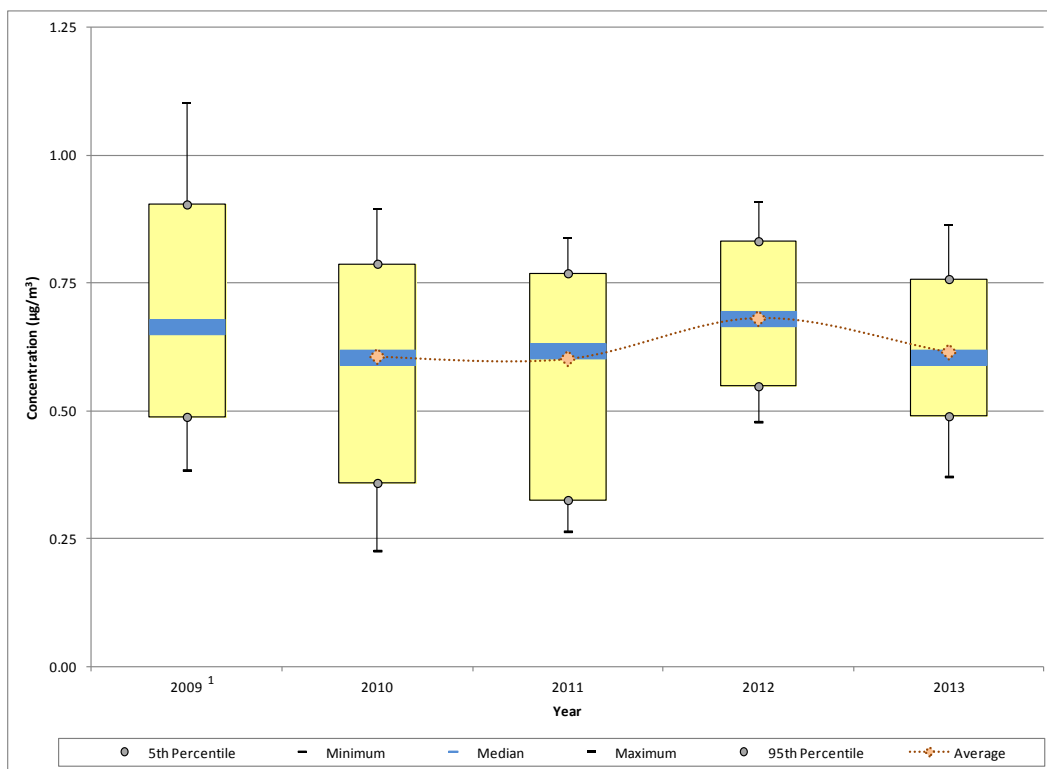


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2009.

Observations from Figure 22-41 for 1,3-butadiene measurements collected at TMOK include the following:

- The range of 1,3-butadiene concentrations measured at TMOK is at a minimum for 2009, with all concentrations measured spanning less than 0.2 $\mu\text{g}/\text{m}^3$, with the range of concentrations measured increasing each year through 2012.
- Even with the increasing range of measurements, the 1-year average concentration of 1,3 butadiene has varied by less than 0.025 $\mu\text{g}/\text{m}^3$ across the years of sampling.
- The number of non-detects has varied across the years of sampling, from a few as none (2009) to as many as nine (2011).

Figure 22-42. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at TMOK

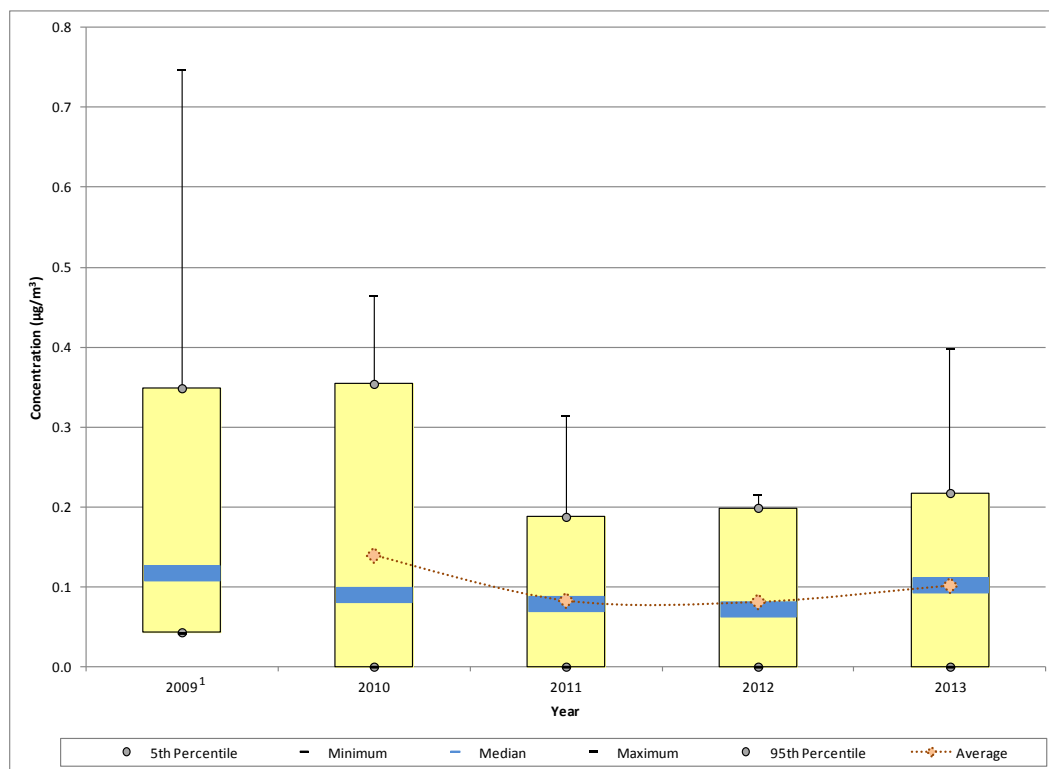


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2009.

Observations from Figure 22-42 for carbon tetrachloride measurements collected at TMOK include the following:

- The maximum carbon tetrachloride concentration was measured on August 17, 2009 and is the only concentration greater than 1 $\mu\text{g}/\text{m}^3$ measured at TMOK.
- All of the statistical parameters exhibit decreases from 2009 to 2010, with little change in the carbon tetrachloride measurements at TMOK shown from 2010 to 2011.
- Even though the range of concentrations measured decreased considerably for 2012, all of the statistical parameters exhibit increases. The 1-year average and median concentrations are equivalent for 2012 (0.68 $\mu\text{g}/\text{m}^3$), which represents a statistically significant increase from 2011.
- All of the statistical parameters exhibit decreases again from 2012 to 2013.
- All of the 1-year average carbon tetrachloride concentrations shown fall between 0.60 $\mu\text{g}/\text{m}^3$ and 0.70 $\mu\text{g}/\text{m}^3$.

Figure 22-43. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at TMOK

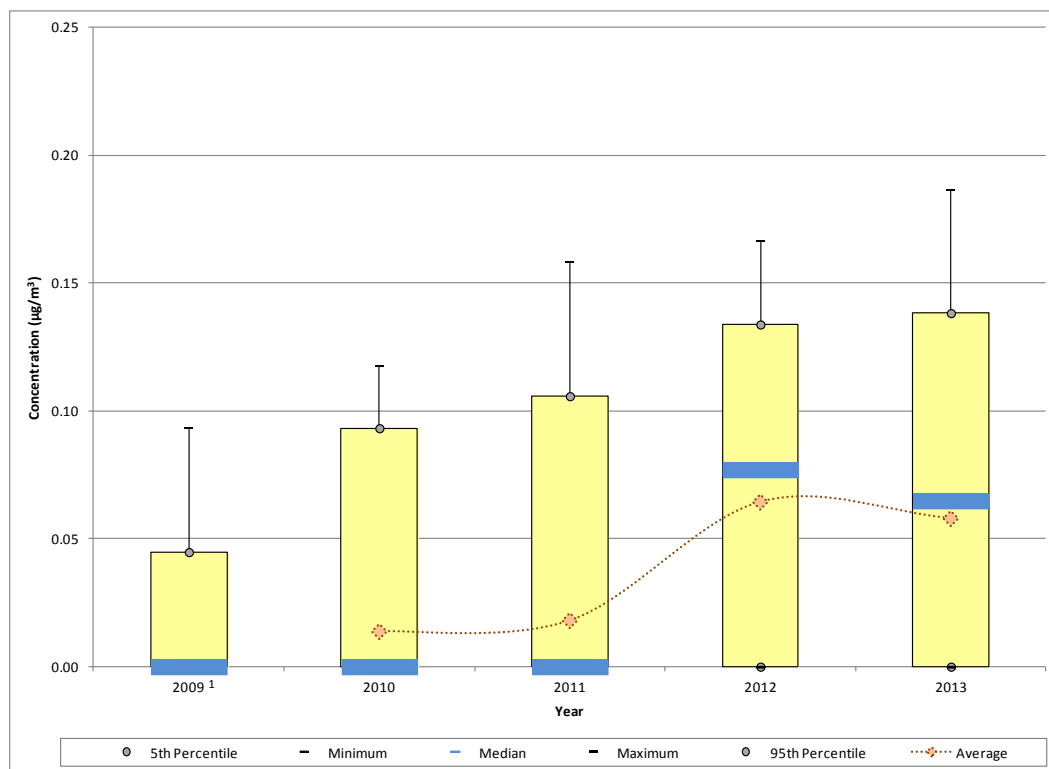


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2009.

Observations from Figure 22-43 for *p*-dichlorobenzene measurements collected at TMOK include the following:

- The maximum *p*-dichlorobenzene concentration was measured on June 30, 2009 (0.75 µg/m³) and is the only measurement greater than 0.5 µg/m³ measured at TMOK.
- The range of concentrations measured at TMOK has decreased every year through 2012. Most of the statistical parameters exhibit a decrease from 2009 to 2010, with many exhibiting further decreases for 2011.
- The 1-year average concentration decreased significantly from 2010 to 2011 with little change shown from 2011 to 2012. Although an increase in the 1-year average concentration is shown for 2013, the difference is not statistically significant.
- The minimum and 5th percentile are both zero for all years of sampling except 2009, indicating the presence of non-detects. Aside from 2009, the number of non-detects has ranged from as few as four in 2010 to as many as 13 in 2011.

Figure 22-44. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at TMOK

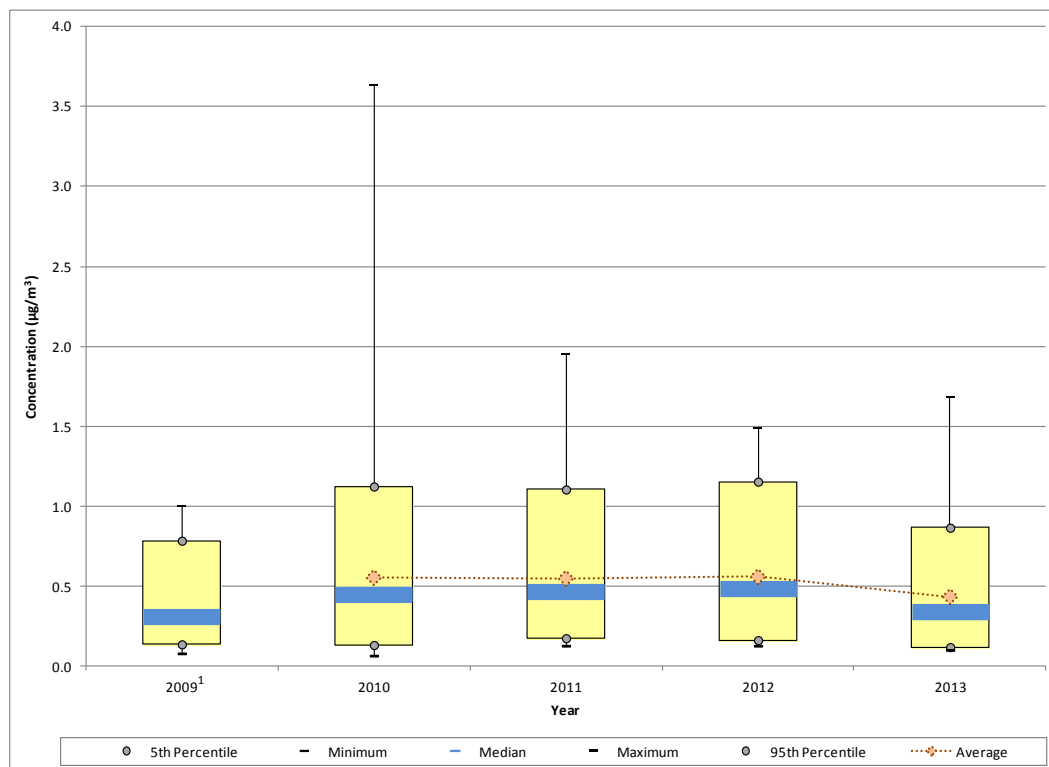


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2009.

Observations from Figure 22-44 for 1,2-dichloroethane measurements collected at TMOK include the following:

- The median concentration for 2009, 2010, and 2011 is zero, indicating that at least half of the measurements were non-detects. In 2009, there were three measured detections of 1,2-dichloroethane. In 2010 and 2011, there were 10. For 2012, the number of measured detections increased by a factor of four. Measured detections also accounted for more than half of measurements in 2013.
- The 1-year average concentration for 2012 is less than the median concentration, which is similar to what was shown for TOOK in 2012. The 1-year average concentration is more susceptible to outliers (on either end of the concentration range) than the median concentration. The 1-year average concentration for 2012 is less than the median, indicating that concentrations on the lower end of the concentration range are pulling the 1-year average down (just like a maximum or outlier concentration can drive the average upward). This is also true for 2013, although the difference between the two statistical parameters is less.

Figure 22-45. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at TMOK

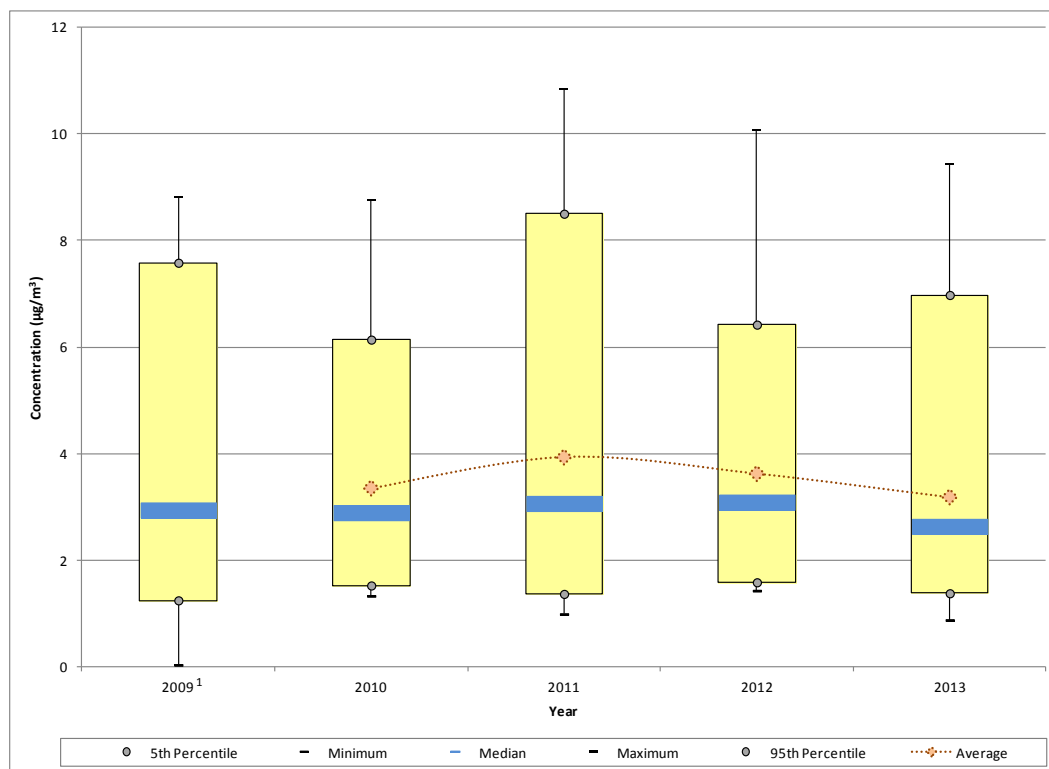


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2009.

Observations from Figure 22-45 for ethylbenzene measurements collected at TMOK include the following:

- The maximum ethylbenzene concentration was measured in 2010 ($3.63 \mu\text{g}/\text{m}^3$) and is the only measurement greater than $2 \mu\text{g}/\text{m}^3$ measured at TMOK.
- Despite the fluctuation in the maximum concentrations shown between 2010 and 2012, little change is shown for most of the statistical parameters. Less than $0.05 \mu\text{g}/\text{m}^3$ separates the median concentrations for these years and roughly $0.01 \mu\text{g}/\text{m}^3$ separates the 1-year average concentrations during this period.
- With the exception of the maximum concentration, all of the statistical parameters exhibit decreases for 2013. The 1-year average concentration is at a minimum for 2013, although confidence intervals calculated for these averages indicate that the decrease from 2012 to 2013 is not statistically significant.

Figure 22-46. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at TMOK

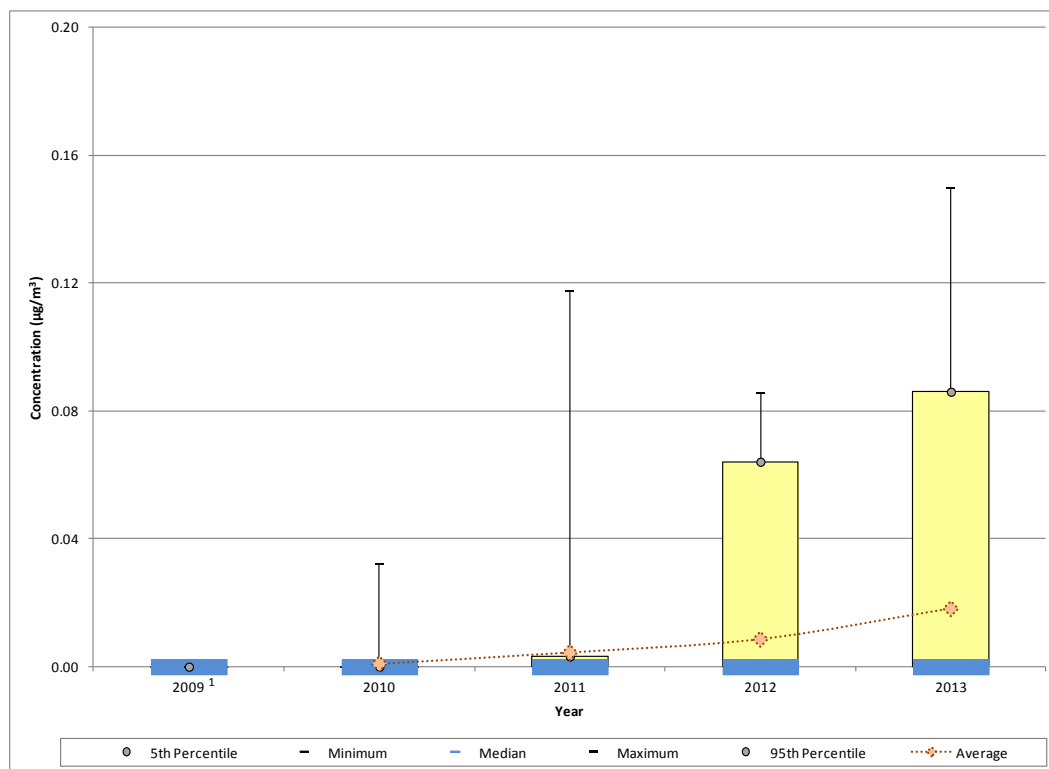


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2009.

Observations from Figure 22-46 for formaldehyde measurements collected at TMOK include the following:

- The maximum formaldehyde concentration was measured on August 19, 2011 ($10.8 \mu\text{g}/\text{m}^3$), the same date that the maximum acetaldehyde concentration was measured at TMOK. Two additional formaldehyde concentrations greater than $10 \mu\text{g}/\text{m}^3$ were measured at TMOK in 2012.
- The 1-year average concentration increased from 2010 to 2011, then has a decreasing trend through 2013, when the 1-year average is at a minimum. However, these changes are not statistically significant. The 1-year average concentrations have ranged from $3.19 \mu\text{g}/\text{m}^3$ (2013) to $3.94 \mu\text{g}/\text{m}^3$ (2011). The median concentration is also at a minimum for 2013, ranging from $2.63 \mu\text{g}/\text{m}^3$ (2013) to $3.09 \mu\text{g}/\text{m}^3$ (2012) across the years of sampling.
- The 1-year average concentrations for formaldehyde exhibit a similar pattern as the 1-year average concentrations for acetaldehyde for TMOK.

Figure 22-47. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at TMOK

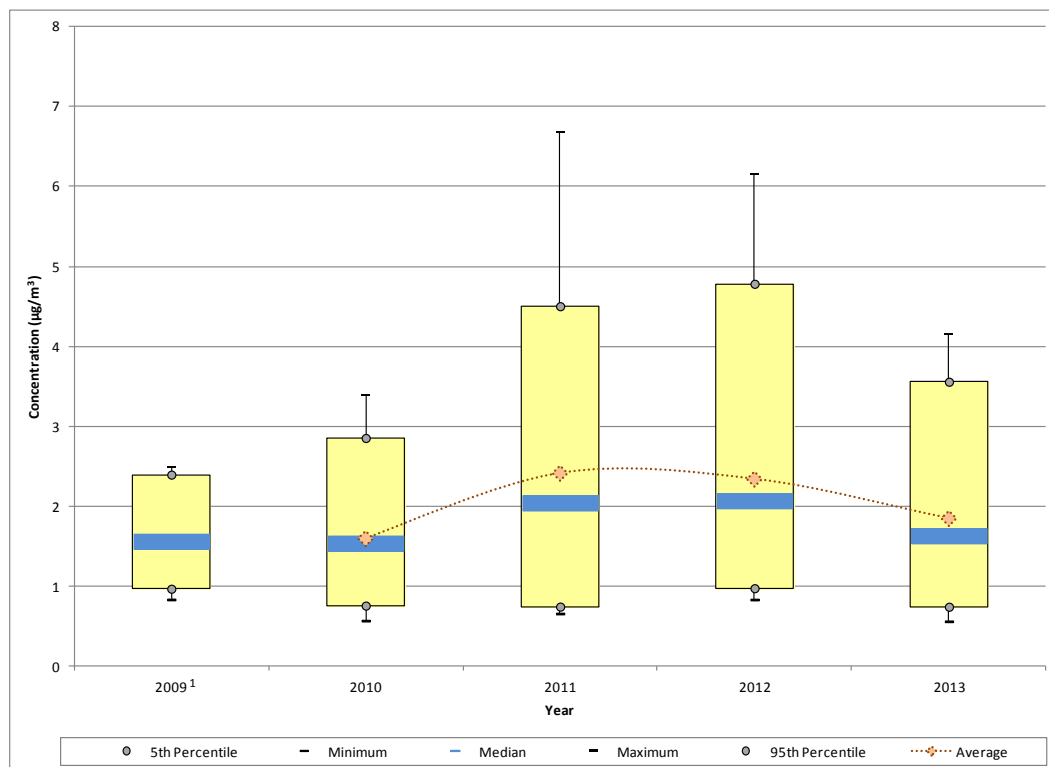


¹ A 1-year average is not presented because sampling under the NMP did not begin until April 2009.

Observations from Figure 22-47 for hexachloro-1,3-butadiene measurements collected at TMOK include the following:

- There were few measured detections in the first few years of sampling at TMOK. The median concentration is zero for all years of sampling, indicating that at least half of the measurements were non-detects for each year. There were no measured detections in 2009, two in 2010, three in 2011, nine in 2012, and 14 in 2013.
- For 2013, more than three-quarters of the measurements are still non-detects and all of the measured detections are less than the MDL.

Figure 22-48. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at OCOK

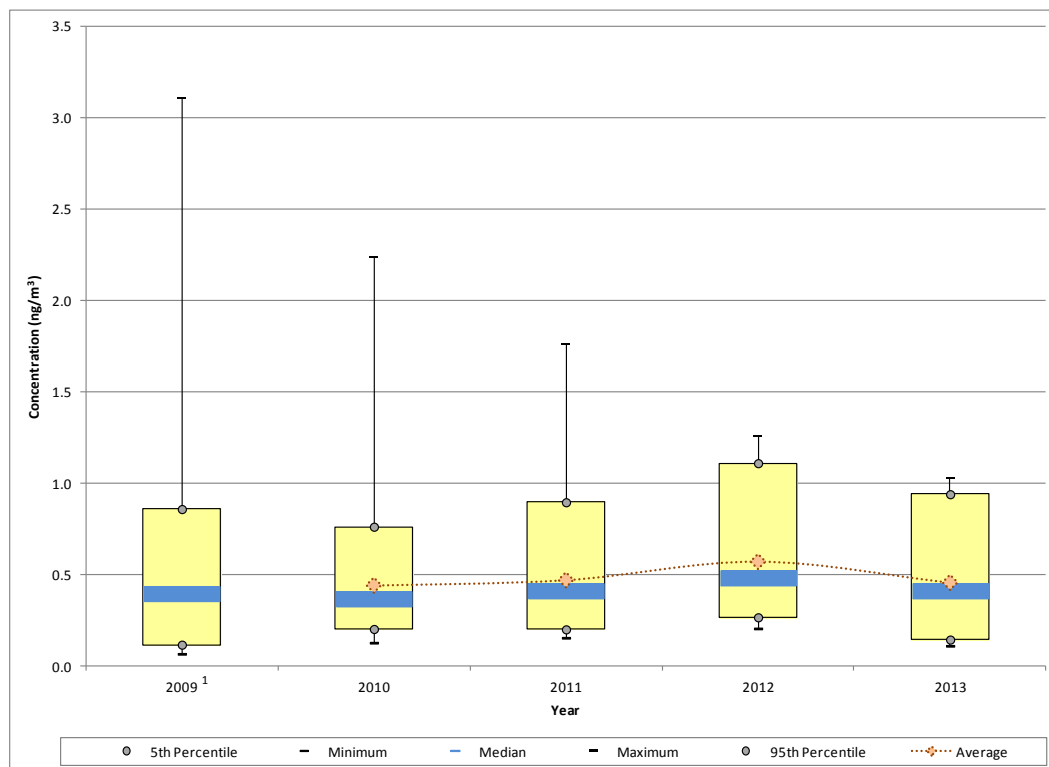


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2009.

Observations from Figure 22-48 for acetaldehyde measurements collected at OCOK include the following:

- Sampling for carbonyl compounds began at OCOK under the NMP in May 2009. A 1-year average concentration is not presented for 2009 because a full year's worth of data is not available, although the range of measurements is provided.
- The maximum acetaldehyde concentration was measured on May 9, 2011 ($6.68 \mu\text{g}/\text{m}^3$). Only one additional acetaldehyde concentration greater than $6 \mu\text{g}/\text{m}^3$ has been measured at OCOK ($6.16 \mu\text{g}/\text{m}^3$ in 2012).
- The smallest range of acetaldehyde concentrations was measured in 2009, after which the range of measurements increased considerably. The 1-year average concentration increased significantly from 2010 to 2011, with the median concentration exhibiting a similar increase. Little change is shown from 2011 to 2012.
- All of the statistical parameters exhibit decreases from 2012 to 2013.

Figure 22-49. Yearly Statistical Metrics for Arsenic (TSP) Concentrations Measured at OCOK

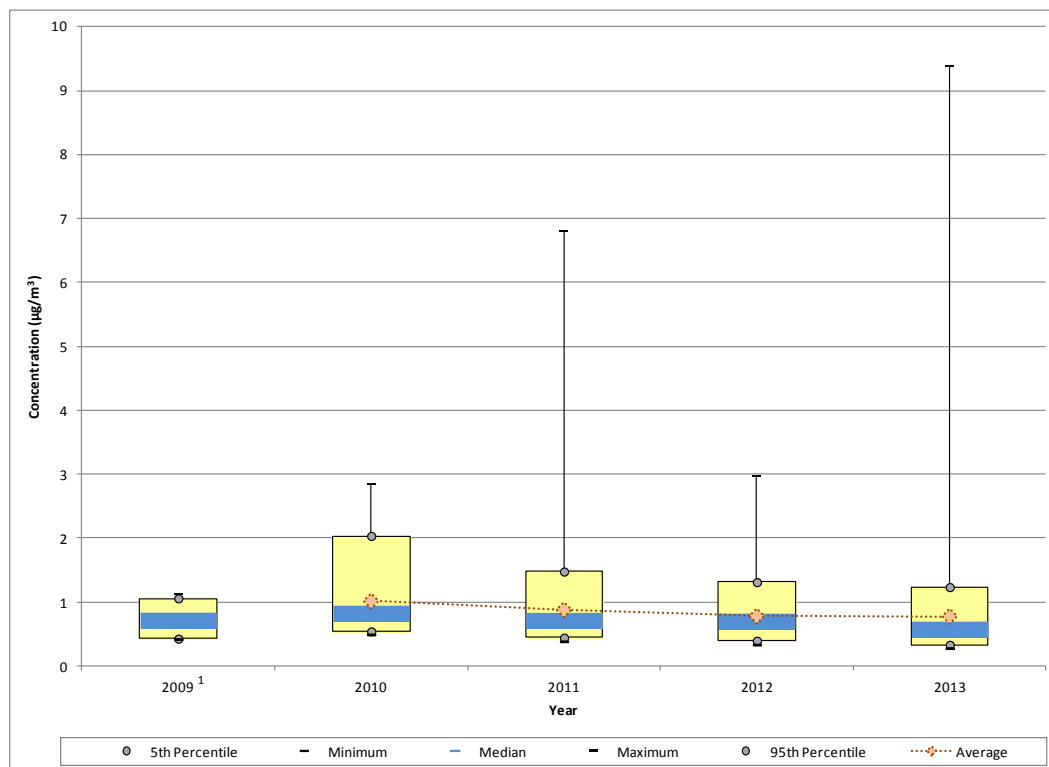


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2009.

Observations from Figure 22-49 for arsenic (TSP) measurements collected at OCOK include the following:

- Sampling for TSP metals began at OCOK under the NMP in May 2009. A 1-year average concentration is not presented for 2009 because a full year's worth of data is not available, although the range of measurements is provided.
- The maximum concentration of arsenic was measured at OCOK in 2009 (3.11 ng/m³). The maximum concentration measured after 2009 has been steadily decreasing, reaching a minimum for 2013 (1.03 ng/m³). At the same time, the minimum concentration measured each year has been steadily increasing, reaching a maximum in 2012 (0.21 ng/m³).
- Although a slight increasing trend is shown in the 1-year average concentrations between 2010 and 2012 and is followed by a slight decrease for 2013, the 1-year average concentrations have varied by less than 0.15 ng/m³, ranging from 0.44 ng/m³ (2010) to 0.57 ng/m³ (2012).

Figure 22-50. Yearly Statistical Metrics for Benzene Concentrations Measured at OCOK

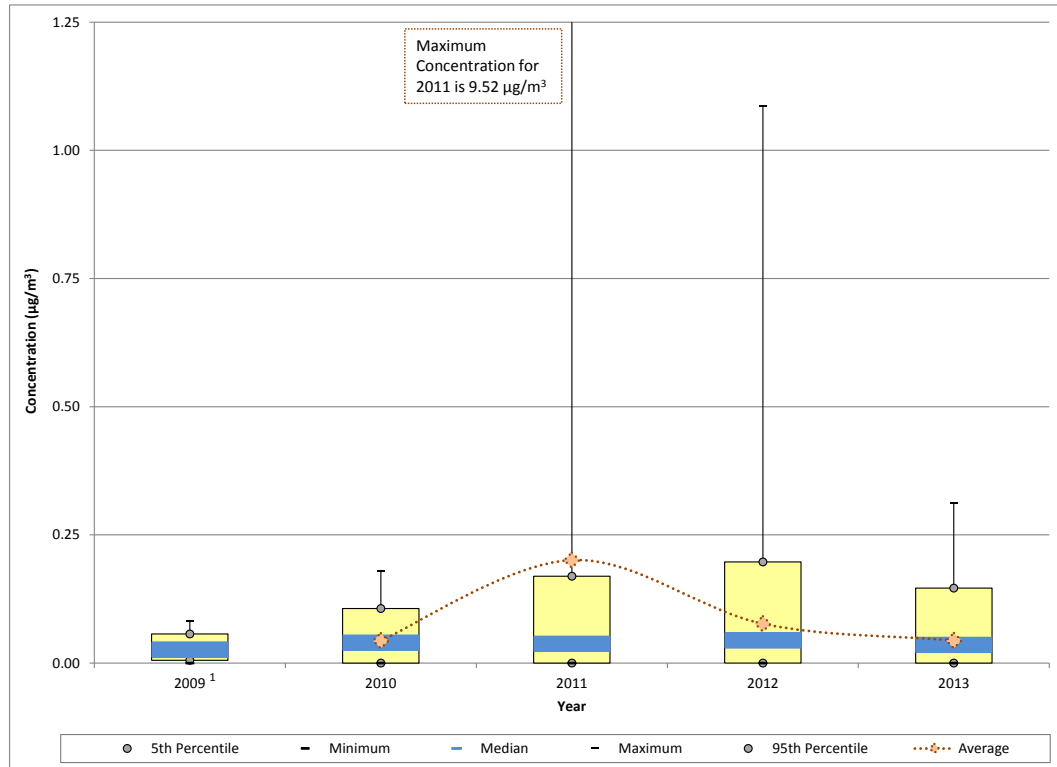


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2009.

Observations from Figure 22-50 for benzene measurements collected at OCOK include the following:

- Sampling for VOCs began at OCOK under the NMP in May 2009. A 1-year average concentration is not presented for 2009 because a full year's worth of data is not available, although the range of measurements is provided.
- The maximum benzene concentration was measured at OCOK on November 6, 2013 ($9.38 \mu\text{g}/\text{m}^3$). The next highest concentration was measured in 2011 ($6.80 \mu\text{g}/\text{m}^3$). No other benzene concentrations greater than $3 \mu\text{g}/\text{m}^3$ have been measured at OCOK.
- Although the range of benzene concentrations measured at OCOK is highly variable, the majority of concentrations (as indicated by the 5th and 95th percentiles) are falling into a tighter range each year (excluding 2009).
- Even though the maximum benzene concentration was measured at OCOK in 2013, both the 1-year average and median concentrations are at a minimum for 2013.
- A decreasing trend in the 1-year average concentrations is shown between 2010 and 2013, although the variability in the measurements results in relatively large confidence intervals, reducing the statistical significance of the changes.

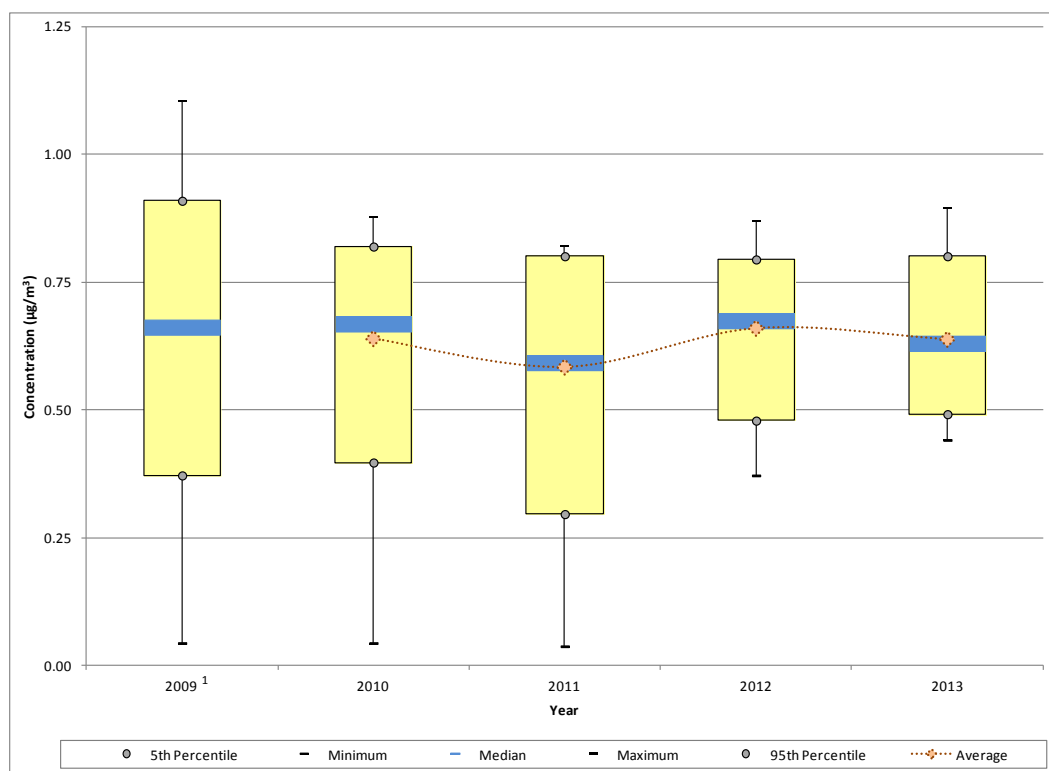
Figure 22-51. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at OCOK



Observations from Figure 22-51 for 1,3-butadiene measurements collected at OCOK include the following:

- The maximum 1,3-butadiene concentration was measured at OCOK on September 18, 2011 (9.52 $\mu\text{g}/\text{m}^3$). The next highest concentration was measured in 2012 (1.09 $\mu\text{g}/\text{m}^3$). No other 1,3-butadiene concentrations greater than 0.5 $\mu\text{g}/\text{m}^3$ have been measured at OCOK.
- The range of concentrations measured at OCOK increased exponentially between 2009 and 2011. Although the range within which the majority of concentrations fall increased as well, as indicated by the difference between the 5th and 95th percentiles, the change is less dramatic.
- The 1-year average concentration for 2011 is being driven by the outlier; if this measurement was excluded from the calculation, the 1-year average concentration would decrease from 0.20 $\mu\text{g}/\text{m}^3$ to 0.05 $\mu\text{g}/\text{m}^3$, resulting in only a slight decrease from 2010 levels.
- The median concentrations shown between 2010 and 2013 have varied by less than 0.01 $\mu\text{g}/\text{m}^3$ over the period, ranging from 0.035 $\mu\text{g}/\text{m}^3$ (2013) to 0.044 $\mu\text{g}/\text{m}^3$ (2012).

Figure 22-52. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at OCOK



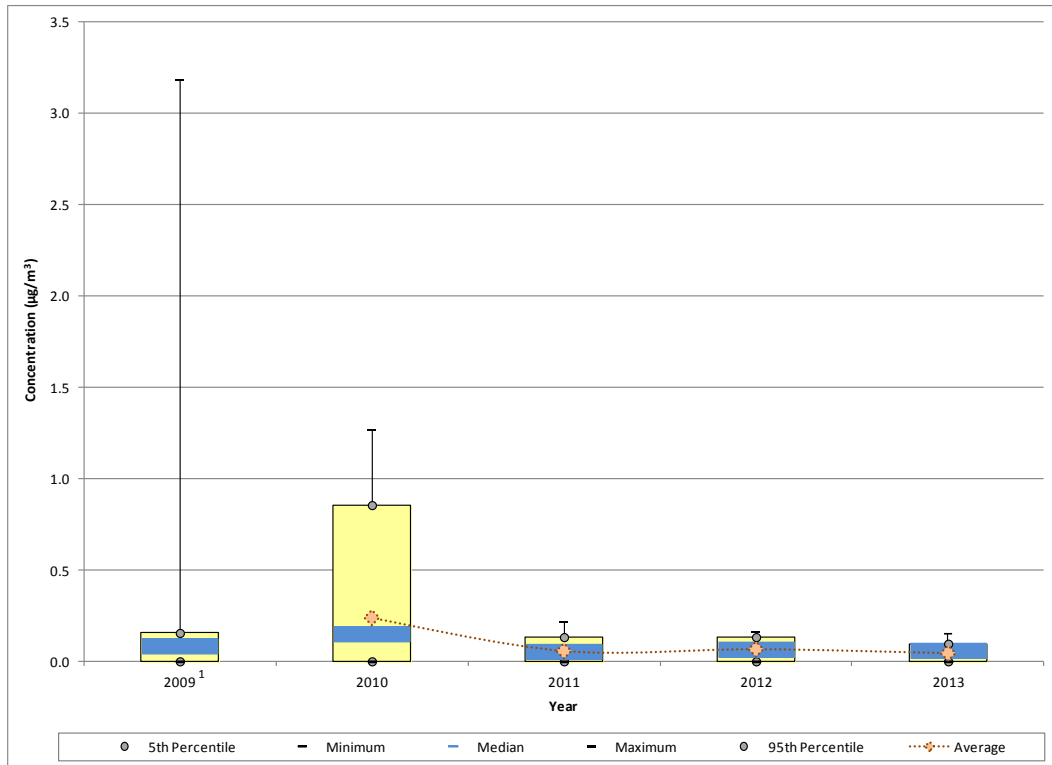
¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2009.

Observations from Figure 22-52 for carbon tetrachloride measurements collected at OCOK include the following:

- The two highest concentrations of carbon tetrachloride were measured at OCOK in 2009, including one greater than $1 \mu\text{g}/\text{m}^3$ ($1.10 \mu\text{g}/\text{m}^3$). The maximum concentrations measured in other years fall between $0.80 \mu\text{g}/\text{m}^3$ and $0.90 \mu\text{g}/\text{m}^3$.
- The range of carbon tetrachloride concentrations measured at OCOK has decreased each year since the onset of sampling, reaching a minimum in 2013, when all carbon tetrachloride concentrations measured spanned less than $0.50 \mu\text{g}/\text{m}^3$.
- The 1-year average concentrations of carbon tetrachloride have varied by less than $0.1 \mu\text{g}/\text{m}^3$, ranging from $0.58 \mu\text{g}/\text{m}^3$ (2011) to $0.66 \mu\text{g}/\text{m}^3$ (2012). The median concentrations have a similar pattern, ranging from $0.59 \mu\text{g}/\text{m}^3$ (2011) to $0.67 \mu\text{g}/\text{m}^3$ (2012).
- With the exception of 2009, the maximum and 95th percentiles have changed little over the years of sampling.
- With the exception of 2013, the median concentration is greater than the 1-year average concentration, which can be attributed to the few concentrations on the lower

end of the range, particularly for 2010 and 2011, which can pull an average down similar to an outlying high concentration.

Figure 22-53. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at OCOK

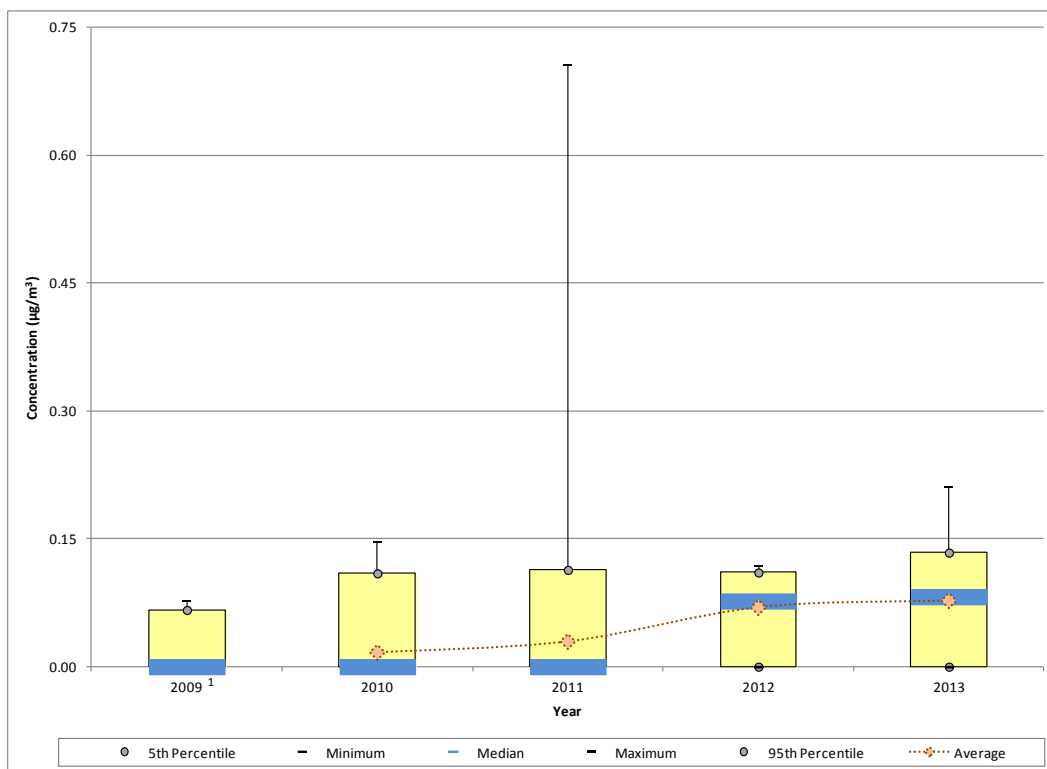


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2009.

Observations from Figure 22-53 for *p*-dichlorobenzene measurements collected at OCOK include the following:

- The maximum *p*-dichlorobenzene concentration was measured at OCOK on September 22, 2009 (3.18 µg/m³). Three concentrations greater than 1 µg/m³ were measured in 2010. No other *p*-dichlorobenzene concentrations greater than 1.0 µg/m³ were measured at OCOK in the years that follow.
- *p*-Dichlorobenzene concentrations measured at OCOK in 2010 were higher than any other years of sampling. The 1-year average concentration calculated for 2010 is greater than the maximum concentration measured for any of the following years. In addition, the median concentration for 2010 is greater than the 95th percentile for any of the following years.
- The range of concentrations measured, the range within which the majority of concentrations fall, and the 1-year average concentration are all at a minimum for 2013.

Figure 22-54. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at OCOK

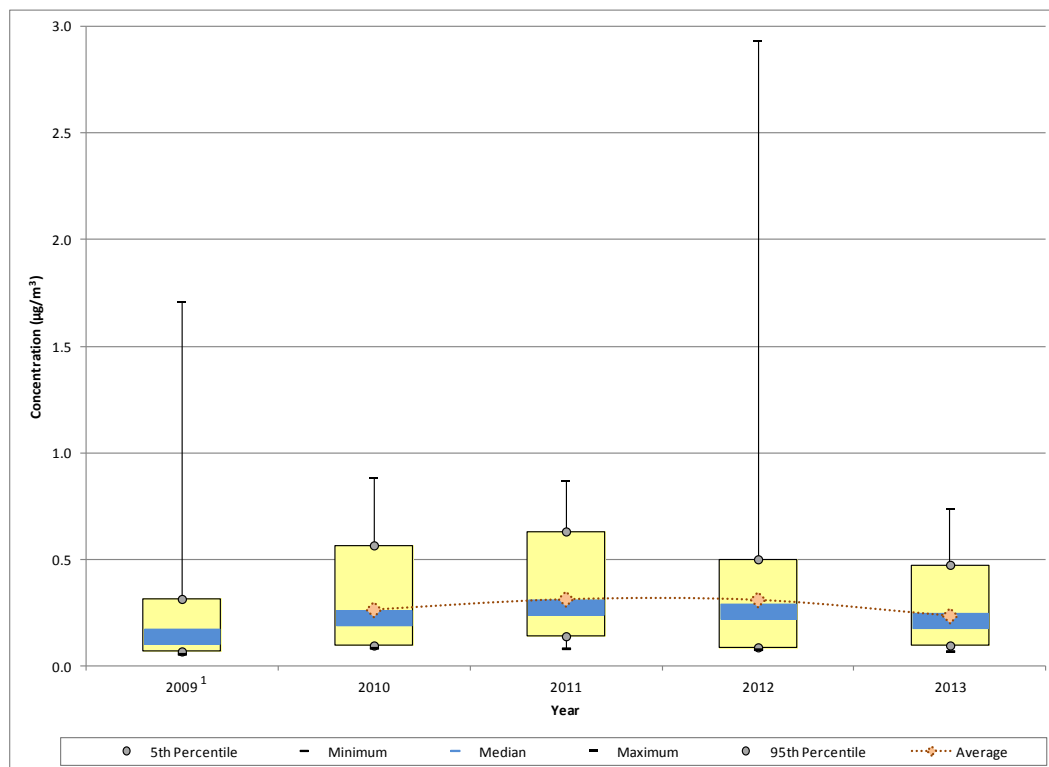


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2009.

Observations from Figure 22-54 for 1,2-dichloroethane measurements collected at OCOK include the following:

- The median concentration for 2009, 2010, and 2011 is zero, indicating that at least half of the measurements were non-detects. In 2009, there were four measured detections of 1,2-dichloroethane, which increased to 11 for 2010 and 13 for 2011. For 2012, the number of measured detections increased by a factor of four (up to 52) and there was a similar number of measured detections for 2013.
- The increase in the measured detections results in an increase in the 1-year average concentrations shown for each year (and for the median concentration for the later years).
- The 95th percentiles changed little between 2010 and 2013, even as a greater number of measured detections were measured.

Figure 22-55. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at OCOK

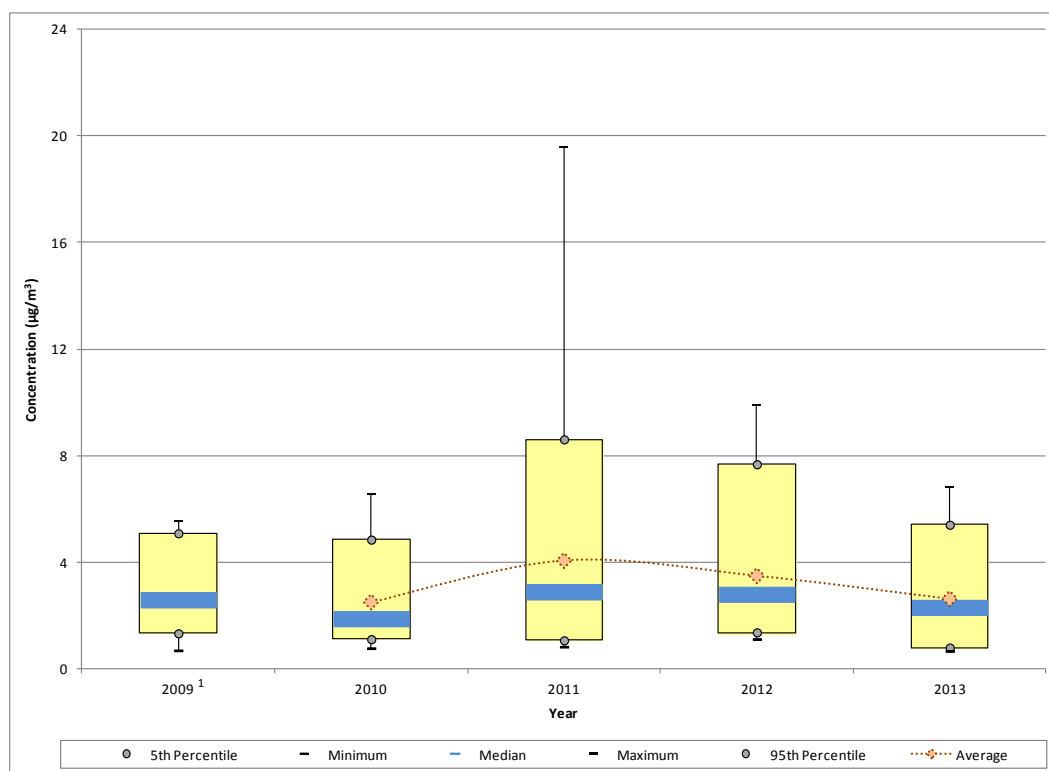


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2009.

Observations from Figure 22-55 for ethylbenzene measurements collected at OCOK include the following:

- The maximum ethylbenzene concentration was measured at OCOK in 2012 ($2.94 \mu\text{g}/\text{m}^3$); only one additional concentration greater than $1 \mu\text{g}/\text{m}^3$ has been measured at OCOK ($1.71 \mu\text{g}/\text{m}^3$ measured in 2009).
- The range of concentrations within which the majority of concentrations fall, as indicated by the difference between the 5th and 95th percentiles, increased between 2009 and 2011 and then decreased through 2013.
- The 1-year average ethylbenzene concentration is at a minimum for 2013 (although it has not changed significantly over the years shown).

Figure 22-56. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at OCOK

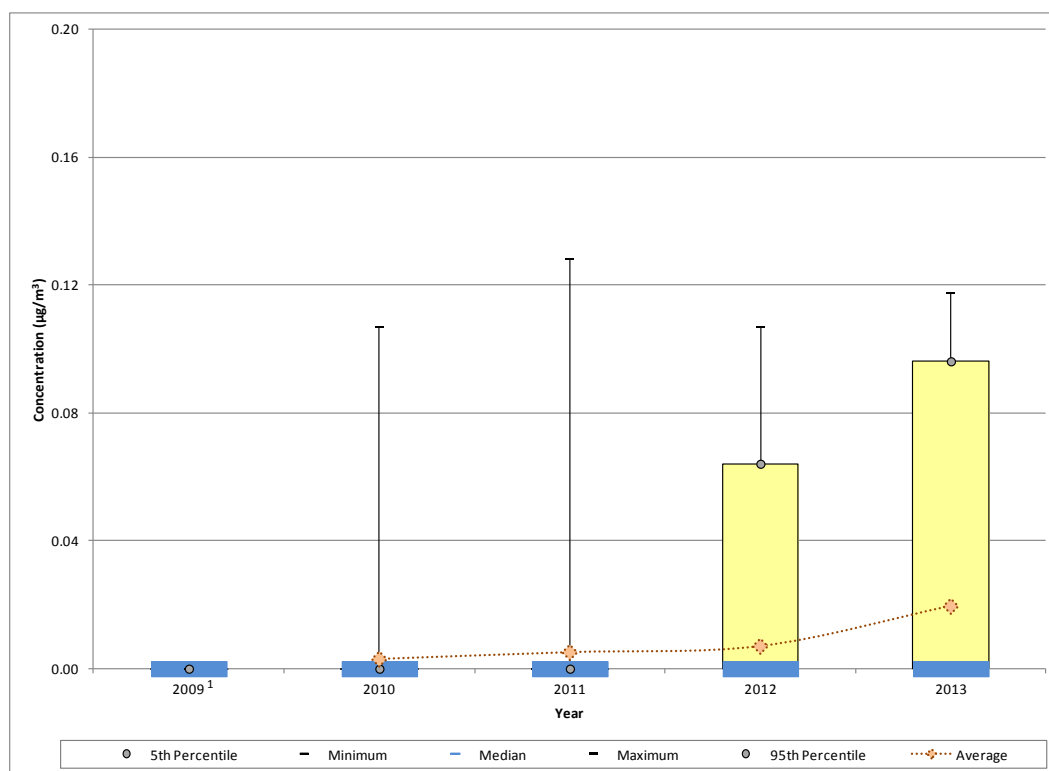


¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2009.

Observations from Figure 22-56 for formaldehyde measurements collected at OCOK include the following:

- The maximum formaldehyde concentration was measured at OCOK in 2011 (19.57 $\mu\text{g}/\text{m}^3$); the only other concentration greater than 10 $\mu\text{g}/\text{m}^3$ was also measured at OCOK in 2011 (10.60 $\mu\text{g}/\text{m}^3$). All 17 formaldehyde concentrations greater than 7 $\mu\text{g}/\text{m}^3$ were measured in either 2011 or 2012.
- With the exception of the 5th percentile, all of the statistical parameters exhibit an increase from 2010 to 2011. This is not just a result of the highest concentrations measured in 2011, as concentrations were higher overall. There were 12 measurements collected in 2011 that were greater than the maximum concentration measured in 2010. The median concentration increased by more than 1 $\mu\text{g}/\text{m}^3$ and the 1-year average concentration increased by more than 60 percent for 2011.
- Concentrations measured in the years following 2011 are lower, as all of the statistical parameters exhibit decreases, particularly at the upper end of the concentration range.

Figure 22-57. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at OCOK



¹ A 1-year average is not presented because sampling under the NMP did not begin until May 2009.

Observations from Figure 22-57 for hexachloro-1,3-butadiene measurements collected at OCOK include the following:

- Few measured detections were measured during the first few years of sampling at OCOK. The median concentration is zero for all years of sampling, indicating that at least half of the measurements were non-detects for each year. There were no measured detections in 2009, two in 2010, three in 2011, seven in 2012, and 14 in 2013.
- For 2013, more than three-quarters of the measurements are non-detects and all of the measured detections are less than the MDL.

22.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at each Oklahoma monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

22.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Oklahoma monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 22-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Observations from Table 22-6 include the following:

- Formaldehyde and acetaldehyde have the highest annual average concentrations for each site (where annual average concentrations could be calculated). Arsenic was the only TSP metal that was identified as a pollutant of interest for all of the Oklahoma sites. Annual average arsenic concentrations were all less than 1 ng/m³.
- Formaldehyde and benzene have the highest cancer risk approximations among the pollutants of interest for the Oklahoma monitoring sites (where annual average concentrations could be calculated). Cancer risk approximations for formaldehyde range from 34.19 in-a-million for OCOK to 41.44 in-a-million for TMOK. TMOK's cancer risk approximation for formaldehyde ranks 10th highest among all cancer risk approximations program-wide. Benzene cancer risk approximations for the Oklahoma monitoring sites range from 6.05 in-a-million for OCOK to 9.44 in-a-million for TOOK.
- For arsenic, the cancer risk approximations range from 0.69 in-a-million for TROK to 3.33 in-a-million for TOOK.

- None of the pollutants of interest have noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The highest noncancer hazard approximation was calculated for formaldehyde for TMOK (0.33).
- Cancer risk and noncancer hazard approximations could not be calculated for ADOK and YUOK.

Table 22-6. Risk Approximations for the Oklahoma Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Public Works, Tulsa, Oklahoma - TOOK						
Acetaldehyde	0.0000022	0.009	61/61	2.02 ± 0.25	4.44	0.22
Benzene	0.0000078	0.03	61/61	1.21 ± 0.17	9.44	0.04
1,3-Butadiene	0.00003	0.002	57/61	0.07 ± 0.01	2.23	0.04
Carbon Tetrachloride	0.000006	0.1	61/61	0.63 ± 0.03	3.75	0.01
1,2-Dichloroethane	0.000026	2.4	34/61	0.06 ± 0.02	1.67	<0.01
Ethylbenzene	0.0000025	1	61/61	0.45 ± 0.06	1.11	<0.01
Formaldehyde	0.000013	0.0098	61/61	2.87 ± 0.44	37.26	0.29
Hexachloro-1,3-butadiene	0.000022	0.09	13/61	0.02 ± 0.01	0.38	<0.01
Arsenic (TSP) ^a	0.0043	0.000015	58/58	0.78 ± 0.07	3.33	0.05
Manganese (TSP) ^a	--	0.0003	58/58	27.59 ± 4.75	--	0.09
Nickel (TSP) ^a	0.00048	0.00009	58/58	2.09 ± 0.42	1.00	0.02

-- = A Cancer URE or Noncancer RfC is not available.

NA = Not available due to the criteria for calculating an annual average.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

Table 22-6. Risk Approximations for the Oklahoma Monitoring Sites (Continued)

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Fire Station, Tulsa, Oklahoma - TMOK						
Acetaldehyde	0.0000022	0.009	61/61	1.94 ± 0.25	4.26	0.22
Benzene	0.0000078	0.03	60/60	0.96 ± 0.12	7.53	0.03
1,3-Butadiene	0.00003	0.002	59/60	0.11 ± 0.02	3.17	0.05
Carbon Tetrachloride	0.000006	0.1	60/60	0.62 ± 0.02	3.69	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	51/60	0.10 ± 0.02	1.12	<0.01
1,2-Dichloroethane	0.000026	2.4	35/60	0.06 ± 0.01	1.58	<0.01
Ethylbenzene	0.0000025	1	60/60	0.43 ± 0.07	1.08	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.19 ± 0.45	41.44	0.33
Hexachloro-1,3-butadiene	0.000022	0.09	14/60	0.02 ± 0.01	0.40	<0.01
Arsenic (TSP) ^a	0.0043	0.000015	56/56	0.65 ± 0.07	2.78	0.04
Riverside, Tulsa, Oklahoma - TROK						
Acetaldehyde	0.0000022	0.009	61/61	1.63 ± 0.20	3.60	0.18
Benzene	0.0000078	0.03	61/61	1.00 ± 0.23	7.84	0.03
1,3-Butadiene	0.00003	0.002	56/61	0.07 ± 0.01	2.17	0.04
Carbon Tetrachloride	0.000006	0.1	61/61	0.61 ± 0.03	3.66	0.01
1,2-Dichloroethane	0.000026	2.4	40/61	0.07 ± 0.01	1.76	<0.01
Ethylbenzene	0.0000025	1	61/61	0.39 ± 0.06	0.99	<0.01
Formaldehyde	0.000013	0.0098	61/61	2.77 ± 0.41	36.03	0.28
Hexachloro-1,3-butadiene	0.000022	0.09	11/61	0.01 ± 0.01	0.29	<0.01
Arsenic (TSP) ^a	0.0043	0.000015	56/56	0.80 ± 0.11	3.42	0.05
Nickel (TSP) ^a	0.00048	0.00009	56/56	1.43 ± 0.24	0.69	0.02

-- = A Cancer URE or Noncancer RfC is not available.

NA = Not available due to the criteria for calculating an annual average.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

Table 22-6. Risk Approximations for the Oklahoma Monitoring Sites (Continued)

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Oklahoma City, Oklahoma - OCOK						
Acetaldehyde	0.0000022	0.009	61/61	1.85 ± 0.23	4.06	0.21
Benzene	0.0000078	0.03	61/61	0.78 ± 0.29	6.05	0.03
1,3-Butadiene	0.00003	0.002	40/61	0.04 ± 0.01	1.32	0.02
Carbon Tetrachloride	0.000006	0.1	61/61	0.64 ± 0.02	3.83	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	39/61	0.05 ± 0.01	0.51	<0.01
1,2-Dichloroethane	0.000026	2.4	51/61	0.08 ± 0.01	2.01	<0.01
Ethylbenzene	0.0000025	1	61/61	0.23 ± 0.03	0.59	<0.01
Formaldehyde	0.000013	0.0098	61/61	2.63 ± 0.41	34.19	0.27
Hexachloro-1,3-butadiene	0.000022	0.09	16/61	0.02 ± 0.01	0.48	<0.01
Arsenic (TSP) ^a	0.0043	0.000015	61/61	0.46 ± 0.06	1.97	0.03
Air Depot, Oklahoma City, Oklahoma - ADOK						
Acetaldehyde	0.0000022	0.009	30/30	NA	NA	NA
Benzene	0.0000078	0.03	30/30	NA	NA	NA
1,3-Butadiene	0.00003	0.002	16/30	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	30/30	NA	NA	NA
<i>p</i> -Dichlorobenzene	0.000011	0.8	29/30	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	28/30	NA	NA	NA
Formaldehyde	0.000013	0.0098	30/30	NA	NA	NA
Arsenic (TSP) ^a	0.0043	0.000015	29/29	NA	NA	NA

-- = A Cancer URE or Noncancer RfC is not available.

NA = Not available due to the criteria for calculating an annual average.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

Table 22-6. Risk Approximations for the Oklahoma Monitoring Sites (Continued)

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Yukon, Oklahoma - YUOK						
Acetaldehyde	0.0000022	0.009	30/30	NA	NA	NA
Benzene	0.0000078	0.03	30/30	NA	NA	NA
1,3-Butadiene	0.00003	0.002	22/30	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	30/30	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	20/30	NA	NA	NA
Formaldehyde	0.000013	0.0098	30/30	NA	NA	NA
Hexachloro-1,3-butadiene	0.000022	0.09	9/30	NA	NA	NA
Arsenic (TSP) ^a	0.0043	0.000015	31/31	NA	NA	NA

-- = A Cancer URE or Noncancer RfC is not available.

NA = Not available due to the criteria for calculating an annual average.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

22.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 22-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 22-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 22-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 22-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 22-7. Table 22-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 22-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Oklahoma Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Public Works, Tulsa, Oklahoma (Tulsa County) - TOOK					
Benzene	642.74	Benzene	5.01E-03	Formaldehyde	37.26
Ethylbenzene	397.71	Hexavalent Chromium	4.29E-03	Benzene	9.44
Formaldehyde	314.78	Formaldehyde	4.09E-03	Acetaldehyde	4.44
Acetaldehyde	183.16	1,3-Butadiene	2.69E-03	Carbon Tetrachloride	3.75
1,3-Butadiene	89.52	Naphthalene	1.08E-03	Arsenic	3.33
Tetrachloroethylene	54.93	Ethylbenzene	9.94E-04	1,3-Butadiene	2.23
Naphthalene	31.71	POM, Group 2b	5.18E-04	1,2-Dichloroethane	1.67
Trichloroethylene	16.89	POM, Group 2d	4.29E-04	Ethylbenzene	1.11
Dichloromethane	8.60	Acetaldehyde	4.03E-04	Nickel	1.00
POM, Group 2b	5.89	Nickel, PM	3.15E-04	Hexachloro-1,3-butadiene	0.38
Fire Station, Tulsa, Oklahoma (Tulsa County) - TMOK					
Benzene	642.74	Benzene	5.01E-03	Formaldehyde	41.44
Ethylbenzene	397.71	Hexavalent Chromium	4.29E-03	Benzene	7.53
Formaldehyde	314.78	Formaldehyde	4.09E-03	Acetaldehyde	4.26
Acetaldehyde	183.16	1,3-Butadiene	2.69E-03	Carbon Tetrachloride	3.69
1,3-Butadiene	89.52	Naphthalene	1.08E-03	1,3-Butadiene	3.17
Tetrachloroethylene	54.93	Ethylbenzene	9.94E-04	Arsenic	2.78
Naphthalene	31.71	POM, Group 2b	5.18E-04	1,2-Dichloroethane	1.58
Trichloroethylene	16.89	POM, Group 2d	4.29E-04	<i>p</i> -Dichlorobenzene	1.12
Dichloromethane	8.60	Acetaldehyde	4.03E-04	Ethylbenzene	1.08
POM, Group 2b	5.89	Nickel, PM	3.15E-04	Hexachloro-1,3-butadiene	0.40

Table 22-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Oklahoma Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Riverside, Tulsa, Oklahoma (Tulsa County) - TROK					
Benzene	642.74	Benzene	5.01E-03	Formaldehyde	36.03
Ethylbenzene	397.71	Hexavalent Chromium	4.29E-03	Benzene	7.84
Formaldehyde	314.78	Formaldehyde	4.09E-03	Carbon Tetrachloride	3.66
Acetaldehyde	183.16	1,3-Butadiene	2.69E-03	Acetaldehyde	3.60
1,3-Butadiene	89.52	Naphthalene	1.08E-03	Arsenic	3.42
Tetrachloroethylene	54.93	Ethylbenzene	9.94E-04	1,3-Butadiene	2.17
Naphthalene	31.71	POM, Group 2b	5.18E-04	1,2-Dichloroethane	1.76
Trichloroethylene	16.89	POM, Group 2d	4.29E-04	Ethylbenzene	0.99
Dichloromethane	8.60	Acetaldehyde	4.03E-04	Nickel	0.69
POM, Group 2b	5.89	Nickel, PM	3.15E-04	Hexachloro-1,3-butadiene	0.29
Air Depot, Oklahoma City, Oklahoma (Oklahoma County) - ADOK					
Benzene	469.97	Benzene	3.67E-03		
Ethylbenzene	297.38	Formaldehyde	3.63E-03		
Formaldehyde	279.17	1,3-Butadiene	1.78E-03		
Acetaldehyde	149.46	Hexavalent Chromium	9.52E-04		
1,3-Butadiene	59.23	Naphthalene	8.47E-04		
Tetrachloroethylene	48.47	Ethylbenzene	7.43E-04		
Naphthalene	24.91	POM, Group 2b	4.40E-04		
Dichloromethane	14.77	POM, Group 2d	3.52E-04		
POM, Group 2b	5.01	Acetaldehyde	3.29E-04		
POM, Group 2d	3.99	Arsenic, PM	2.40E-04		

Table 22-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Oklahoma Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Oklahoma City, Oklahoma (Oklahoma County) - OCOK					
Benzene	469.97	Benzene	3.67E-03	Formaldehyde	34.19
Ethylbenzene	297.38	Formaldehyde	3.63E-03	Benzene	6.05
Formaldehyde	279.17	1,3-Butadiene	1.78E-03	Acetaldehyde	4.06
Acetaldehyde	149.46	Hexavalent Chromium	9.52E-04	Carbon Tetrachloride	3.83
1,3-Butadiene	59.23	Naphthalene	8.47E-04	1,2-Dichloroethane	2.01
Tetrachloroethylene	48.47	Ethylbenzene	7.43E-04	Arsenic	1.97
Naphthalene	24.91	POM, Group 2b	4.40E-04	1,3-Butadiene	1.32
Dichloromethane	14.77	POM, Group 2d	3.52E-04	Ethylbenzene	0.59
POM, Group 2b	5.01	Acetaldehyde	3.29E-04	p-Dichlorobenzene	0.51
POM, Group 2d	3.99	Arsenic, PM	2.40E-04	Hexachloro-1,3-butadiene	0.48
Yukon, Oklahoma (Canadian County) - YUOK					
Formaldehyde	153.30	Formaldehyde	1.99E-03		
Benzene	69.83	Benzene	5.45E-04		
Acetaldehyde	50.89	1,3-Butadiene	3.53E-04		
Ethylbenzene	34.53	Naphthalene	1.61E-04		
1,3-Butadiene	11.75	Acetaldehyde	1.12E-04		
Naphthalene	4.72	Ethylbenzene	8.63E-05		
Tetrachloroethylene	2.35	POM, Group 2b	8.61E-05		
POM, Group 2b	0.98	POM, Group 2d	7.69E-05		
Dichloromethane	0.88	POM, Group 5a	5.54E-05		
POM, Group 2d	0.87	Arsenic, PM	2.78E-05		

Table 22-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Oklahoma Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Public Works, Tulsa, Oklahoma (Tulsa County) - TOOK					
Toluene	2,096.03	Acrolein	869,130.16	Formaldehyde	0.29
Xylenes	1,502.33	1,3-Butadiene	44,761.98	Acetaldehyde	0.22
Hexane	862.22	Formaldehyde	32,120.04	Manganese	0.09
Benzene	642.74	Benzene	21,424.75	Arsenic	0.05
Ethylbenzene	397.71	Acetaldehyde	20,350.75	Benzene	0.04
Methanol	360.45	Xylenes	15,023.31	1,3-Butadiene	0.04
Formaldehyde	314.78	Naphthalene	10,570.68	Nickel	0.02
Acetaldehyde	183.16	Trichloroethylene	8,445.87	Carbon Tetrachloride	0.01
Ethylene glycol	120.05	Nickel, PM	7,292.24	Ethylbenzene	<0.01
1,3-Butadiene	89.52	Lead, PM	5,904.21	Hexachloro-1,3-butadiene	<0.01
Fire Station, Tulsa, Oklahoma (Tulsa County) - TMOK					
Toluene	2,096.03	Acrolein	869,130.16	Formaldehyde	0.33
Xylenes	1,502.33	1,3-Butadiene	44,761.98	Acetaldehyde	0.22
Hexane	862.22	Formaldehyde	32,120.04	1,3-Butadiene	0.05
Benzene	642.74	Benzene	21,424.75	Arsenic	0.04
Ethylbenzene	397.71	Acetaldehyde	20,350.75	Benzene	0.03
Methanol	360.45	Xylenes	15,023.31	Carbon Tetrachloride	0.01
Formaldehyde	314.78	Naphthalene	10,570.68	Ethylbenzene	<0.01
Acetaldehyde	183.16	Trichloroethylene	8,445.87	Hexachloro-1,3-butadiene	<0.01
Ethylene glycol	120.05	Nickel, PM	7,292.24	<i>p</i> -Dichlorobenzene	<0.01
1,3-Butadiene	89.52	Lead, PM	5,904.21	1,2-Dichloroethane	<0.01

Table 22-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Oklahoma Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Riverside, Tulsa, Oklahoma (Tulsa County) - TROK					
Toluene	2,096.03	Acrolein	869,130.16	Formaldehyde	0.28
Xylenes	1,502.33	1,3-Butadiene	44,761.98	Acetaldehyde	0.18
Hexane	862.22	Formaldehyde	32,120.04	Arsenic	0.05
Benzene	642.74	Benzene	21,424.75	1,3-Butadiene	0.04
Ethylbenzene	397.71	Acetaldehyde	20,350.75	Benzene	0.03
Methanol	360.45	Xylenes	15,023.31	Nickel	0.02
Formaldehyde	314.78	Naphthalene	10,570.68	Carbon Tetrachloride	0.01
Acetaldehyde	183.16	Trichloroethylene	8,445.87	Ethylbenzene	<0.01
Ethylene glycol	120.05	Nickel, PM	7,292.24	Hexachloro-1,3-butadiene	<0.01
1,3-Butadiene	89.52	Lead, PM	5,904.21	1,2-Dichloroethane	<0.01
Air Depot, Oklahoma City, Oklahoma (Oklahoma County) - ADOK					
Toluene	1,716.89	Acrolein	825,550.98		
Xylenes	1,179.06	1,3-Butadiene	29,617.41		
Hexane	800.82	Formaldehyde	28,486.41		
Benzene	469.97	Acetaldehyde	16,606.84		
Methanol	444.71	Benzene	15,665.51		
Ethylbenzene	297.38	Xylenes	11,790.55		
Formaldehyde	279.17	Naphthalene	8,303.68		
Ethylene glycol	202.30	Arsenic, PM	3,725.81		
Acetaldehyde	149.46	Nickel, PM	3,115.38		
Methyl isobutyl ketone	71.17	Propionaldehyde	2,411.31		

Table 22-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Oklahoma Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Oklahoma City, Oklahoma (Oklahoma County) - OCOK					
Toluene	1,716.89	Acrolein	825,550.98	Formaldehyde	0.27
Xylenes	1,179.06	1,3-Butadiene	29,617.41	Acetaldehyde	0.21
Hexane	800.82	Formaldehyde	28,486.41	Arsenic	0.03
Benzene	469.97	Acetaldehyde	16,606.84	Benzene	0.03
Methanol	444.71	Benzene	15,665.51	1,3-Butadiene	0.02
Ethylbenzene	297.38	Xylenes	11,790.55	Carbon Tetrachloride	0.01
Formaldehyde	279.17	Naphthalene	8,303.68	Hexachloro-1,3-butadiene	<0.01
Ethylene glycol	202.30	Arsenic, PM	3,725.81	Ethylbenzene	<0.01
Acetaldehyde	149.46	Nickel, PM	3,115.38	<i>p</i> -Dichlorobenzene	<0.01
Methyl isobutyl ketone	71.17	Propionaldehyde	2,411.31	1,2-Dichloroethane	<0.01
Yukon, Oklahoma (Canadian County) - YUOK					
Xylenes	270.61	Acrolein	960,699.47		
Toluene	218.04	Formaldehyde	15,642.59		
Formaldehyde	153.30	1,3-Butadiene	5,876.61		
Hexane	119.27	Acetaldehyde	5,654.44		
Methanol	80.71	Xylenes	2,706.07		
Benzene	69.83	Benzene	2,327.52		
Acetaldehyde	50.89	Naphthalene	1,574.09		
Ethylbenzene	34.53	Cyanide Compounds, gas	1,510.86		
Ethylene glycol	22.94	Lead, PM	1,020.34		
Acrolein	19.21	Arsenic, PM	430.77		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 22.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 22-7 include the following:

- Benzene is the highest emitted pollutant with a cancer URE in Tulsa and Oklahoma Counties, followed by ethylbenzene and formaldehyde. The highest emitted pollutants in Canadian County are formaldehyde, benzene, and acetaldehyde. The quantity of emissions is highest in Tulsa County and lowest in Canadian County.
- The pollutant with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Tulsa County is benzene, followed by hexavalent chromium and formaldehyde. The pollutant with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Oklahoma County is also benzene, followed by formaldehyde and 1,3-butadiene. The pollutant with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Canadian County is formaldehyde, followed by benzene and 1,3-butadiene.
- Seven of the highest emitted pollutants in Tulsa County also have the highest toxicity-weighted emissions. Eight of the highest emitted pollutants in Oklahoma County also have the highest toxicity-weighted emissions. Eight of the highest emitted pollutants in Canadian County also have the highest toxicity-weighted emissions.
- Formaldehyde and benzene have the highest cancer risk approximations among the Oklahoma sites' pollutants of interest (where risk approximations could be calculated). Both of these pollutants appear at or near the top of both emissions-based lists for each county. Acetaldehyde, 1,3-butadiene, and ethylbenzene also appear on all three lists for TOOK, TMOK, TROK, and OCOK.
- Nickel is a pollutant of interest for TOOK and TROK and has one of the higher cancer risk approximations for each site. Nickel has the 10th highest toxicity-weighted emissions for Tulsa County but is not among the highest emitted (its emissions rank 12th).
- Carbon tetrachloride, arsenic, 1,2-dichloroethane, and hexachloro-1,3-butadiene are pollutants of interest for each site and have one of the higher cancer risk

approximations for each site but do not appear on either emissions-based site. *p*-Dichlorobenzene is a pollutant of interest for TMOK and OCOK that appears on neither emissions-based list.

- Naphthalene and several POM Groups appear in Table 22-7 for quantity emitted and toxicity-weighted emissions. PAHs were not sampled for under the NMP at the Oklahoma sites.

Observations from Table 22-8 include the following:

- Toluene and xylenes are the highest emitted pollutants with noncancer RfCs in Tulsa and Oklahoma Counties, while the order was reversed for Canadian County. Emissions were generally highest in Tulsa County and lowest in Canadian County.
- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for all three counties. Acrolein has the highest toxicity-weighted emissions for almost all counties with NMP sites but appears among the highest emitted for only two. Canadian County is one of those counties, with acrolein ranking 10th among those with the highest emissions. Compared to other counties with NMP sites, Canadian County's acrolein emissions are not exceedingly high (19.21 tpy), but are the 15th highest for counties for NMP sites and are slightly higher than the emissions for Tulsa County (17.38 tpy) and Oklahoma County (16.51 tpy). Acrolein was sampled for at all of the Oklahoma sites, but this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.
- Four of the highest emitted pollutants in Oklahoma County also have the highest toxicity-weighted emissions; five of the highest emitted pollutants in Tulsa County and Canadian County also have the highest toxicity-weighted emissions. Note that although toluene is one of, if not the highest emitted pollutant in all three counties, this pollutant does not appear among those with the highest toxicity-weighted emissions.
- Formaldehyde and acetaldehyde have the highest noncancer hazard approximations among the Oklahoma sites (where they could be calculated). These pollutants appear on both emissions-based lists for each county. Benzene and 1,3-butadiene also appear on all three lists for TOOK, TMOK, and TROK. 1,3-Butadiene has one of the highest noncancer hazard approximations for OCOK, and has some of the highest toxicity-weighted emissions for Oklahoma County but is not one of the 10 highest emitted in that county (but is just outside the list at 11th highest).
- Several metals appear among the pollutants with the highest toxicity-weighted emissions for each county but no metals are listed among the highest emitted pollutants for any of the three counties. This speaks to the relative toxicity of the speciated metals. Note that for the metals, the emissions-based lists are PM₁₀ while the Oklahoma sites sampled TSP metals.

22.6 Summary of the 2013 Monitoring Data for the Oklahoma Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *Seventeen pollutants failed at least one screen for TOOK; 15 pollutants failed screens for TMOK; 14 pollutants failed screens for TROK; 12 pollutants failed screens for ADOK; 16 pollutants failed screens for OCOK; and 11 pollutants failed screens for YUOK. Sampling at ADOK and YUOK includes only half of a year's worth of sampling due to the mid-year relocation of the sampling instrumentation from ADOK to YUOK.*
- ❖ *Formaldehyde and acetaldehyde had the highest annual average concentrations for each site. Concentrations of these carbonyl compounds tended to be higher during the warmer months of the year.*
- ❖ *After several years of increasing, concentrations of acetaldehyde, ethylbenzene, and manganese decreased at TOOK for 2013. Other pollutants exhibit this trend as well but the difference is less significant. Benzene concentrations measured at TOOK have been decreasing over the last few years. Benzene concentrations have also been decreasing at TMOK. In addition, the detection rates of 1,2-dichloroethane and hexachloro-1,3-butadiene have been increasing at TOOK, TMOK, and OCOK over the last few years of sampling, particularly for 1,2-dichloroethane. Concentrations of the acetaldehyde and formaldehyde have also been decreasing at OCOK.*
- ❖ *Formaldehyde has the highest cancer risk approximation among the site-specific pollutants of interest for each site. None of the pollutants of interest have noncancer hazard approximations greater than an HQ of 1.0.*

23.0 Site in Rhode Island

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Rhode Island, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

23.1 Site Characterization

This section characterizes the Rhode Island monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The PRRI monitoring site is located in south Providence. Figure 23-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 23-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 23-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 23-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 23-1. Providence, Rhode Island (PRRI) Monitoring Site

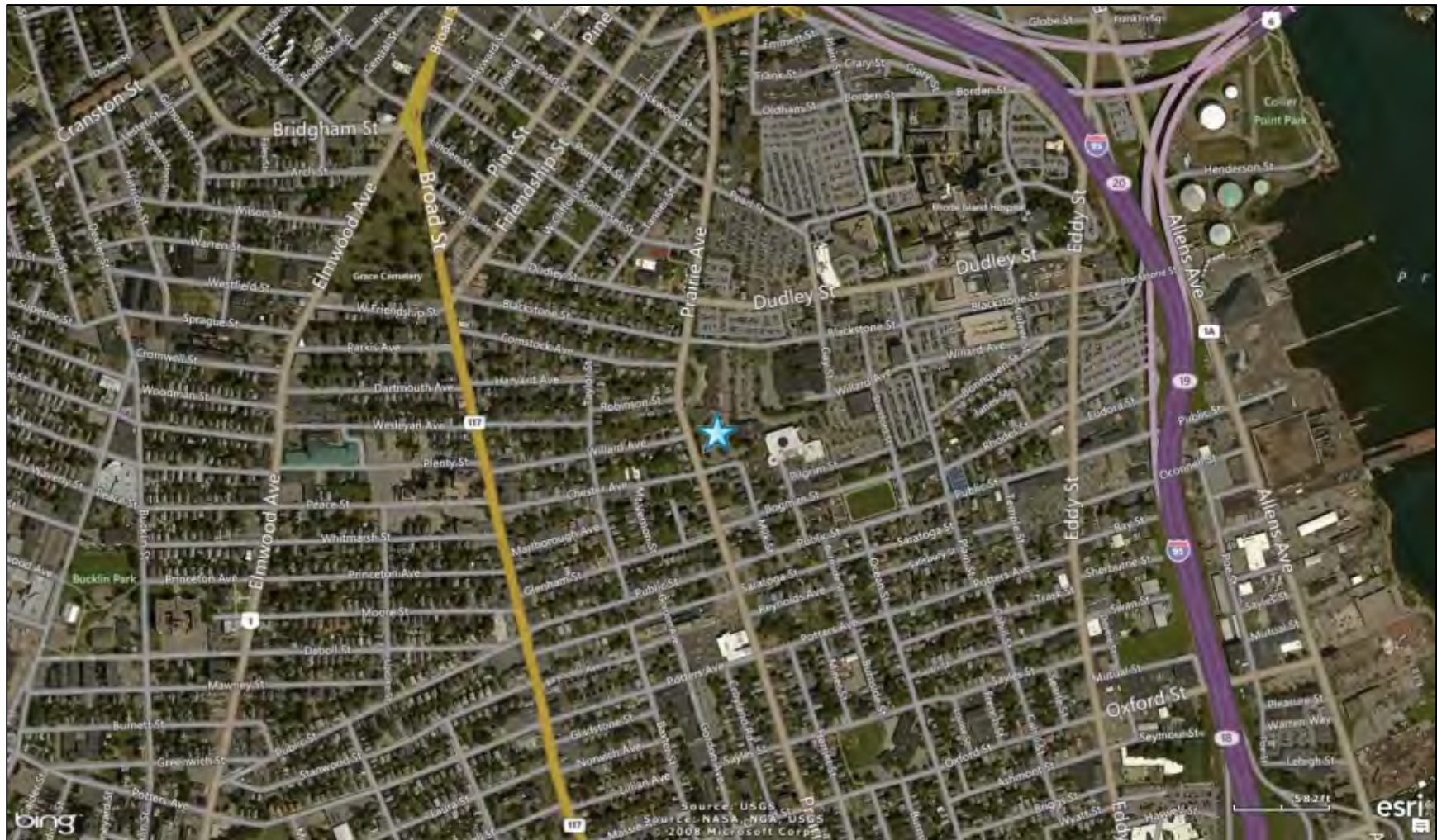


Figure 23-2. NEI Point Sources Located Within 10 Miles of PRRI

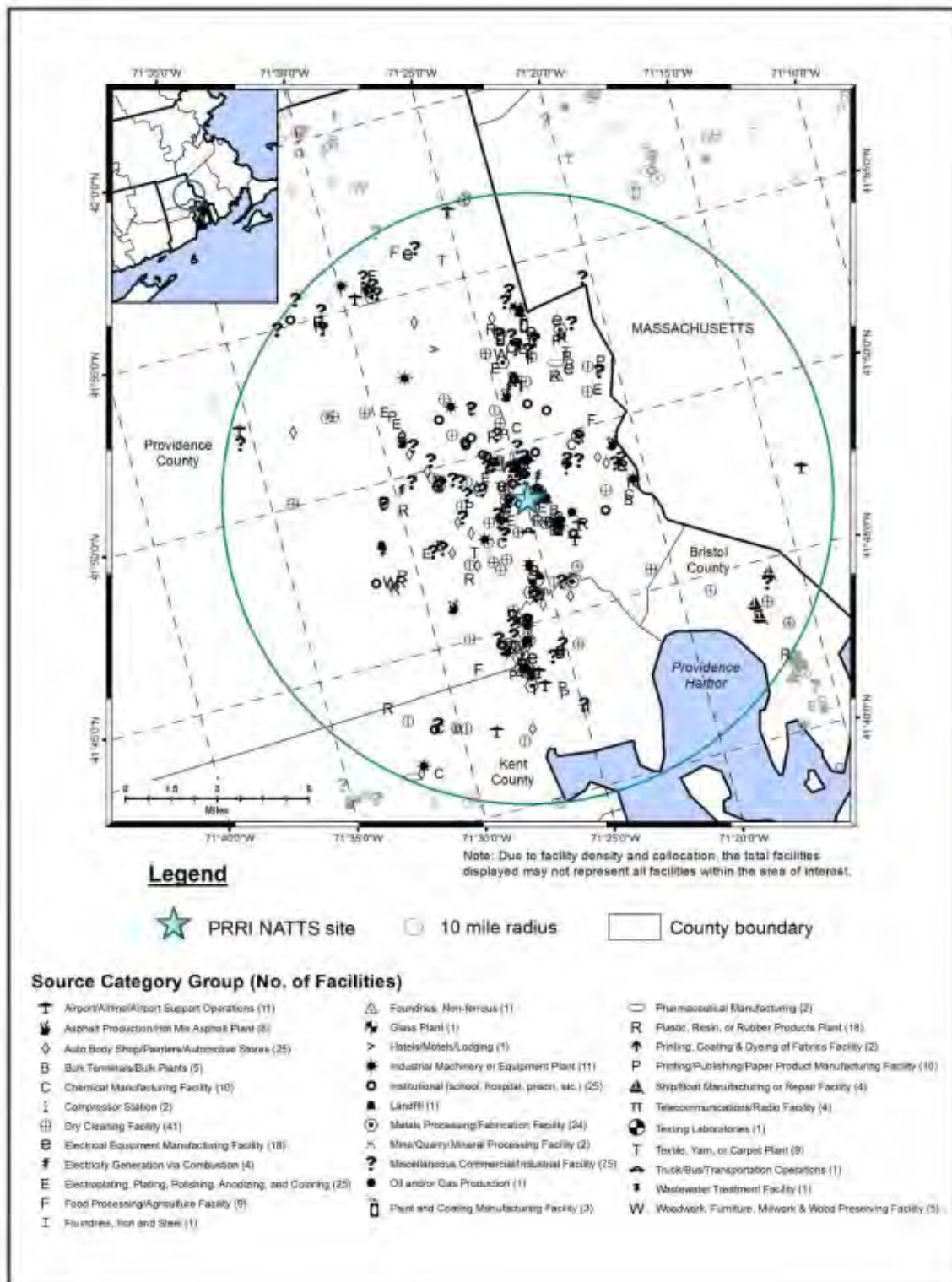


Table 23-1. Geographical Information for the Rhode Island Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>PRRI</i>	44-007-0022	Providence	Providence	Providence-Warwick, RI-MA	41.807776, -71.415105	Residential	Urban/City Center	PAMS, VOCs, Carbonyl Compounds, Meteorological parameters, PM ₁₀ , PM ₁₀ Speciation, Black Carbon, PM _{2.5} , PM _{2.5} Speciation, SNMOC.

¹ Data for additional pollutants are reported to AQS for PRRI (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

Figure 23-1 shows that the areas to the west and south of PRRI are primarily residential, but areas to the north and east are commercial. A hospital lies to the northeast of the site, just north of Dudley Street. Interstate-95 runs north-south about one-half mile to the east of the site, then turns northwestward, entering downtown Providence. The Providence Harbor is just on the other side of I-95 and can be seen on the right-hand side of Figure 23-1. Figure 23-2 shows that a large number of point sources are located within 10 miles of PRRI, most of which are within about 5 miles of the site. The source categories with the greatest number of point sources within 10 miles of PRRI include dry cleaners; institutions (such as schools, prisons, and hospitals); metals processing and fabrication facilities; electroplating, plating, polishing, anodizing, and coloring facilities; and auto body shops, painters, and automotive stores. Sources within one-half mile of PRRI include several hospitals, a heliport at a hospital, a bulk terminal/bulk plant, an electroplating, plating, polishing, anodizing, and coloring facility, and a facility that falls into the miscellaneous commercial and industrial source category.

Table 23-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Rhode Island monitoring site. Table 23-2 includes the county-level population for the site. County-level vehicle registration data for Providence County were not available from the State of Rhode Island. Thus, state-level vehicle registration, which was obtained from the Federal Highway Administration, was allocated to the county level using the county-level proportion of the state population from the U.S. Census Bureau. Table 23-2 also contains traffic volume information for PRRI as well as the location for which the traffic volume was obtained. Additionally, Table 23-2 presents county-level daily VMT for Providence County from the 2011 NEI.

Table 23-2. Population, Motor Vehicle, and Traffic Information for the Rhode Island Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
<i>PRRI</i>	Providence	628,600	511,015	136,800	I-95 near I-195	11,670,714

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration is a ratio based on 2012 state-level vehicle registration data from the FHWA and the 2012 county-level proportion of the state population data (FHWA, 2014 and Census Bureau, 2013c)

³AADT reflects 2009 data (RI DOT, 2009)

⁴County-level VMT reflects 2011 data (EPA, 2015a)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 23-2 include the following:

- Providence County's population is in the middle of the range compared to other counties with NMP sites.
- The estimated county-level vehicle registration is also in the middle of the range compared to other counties with NMP sites.
- The traffic volume experienced near PRRI is the ninth highest compared to traffic volumes near other NMP monitoring sites. The traffic estimate provided is for I-95 near the I-195 interchange.
- The daily VMT for Providence County is 11.7 million miles and ranks in the middle of the range compared to other counties with NMP sites.

23.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Rhode Island on sample days, as well as over the course of the year.

23.2.1 Climate Summary

Providence is a coastal city on the Narragansett Bay, which opens to the Rhode Island Sound and the Atlantic Ocean. The city's proximity to these bodies of water temper cold air outbreaks, and breezes off the ocean moderate summertime heat. On average, southerly and southwesterly winds in the summer become west-northwesterly in the winter. Storm systems frequently affect the New England region, producing variable weather. Precipitation occurs in Providence about once every 3 days and is distributed rather evenly throughout the year. Thunderstorms are common between May and August, while coastal storms during the cooler months tend to produce the greatest amounts of rain and snow. Thirty inches of snow is typical in winter (Wood, 2004; CoCoRaHS, 2011).

23.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Rhode Island monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station is located at Theodore F. Green State Airport (WBAN 14765). Additional information about the T.F. Green Airport weather station, such as the distance between the site and the weather station, is provided in Table 23-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 23-3. Average Meteorological Conditions near the Rhode Island Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Providence, Rhode Island - PRRI									
Theodore F. Green State Airport 14765 (41.72, -71.43)	6.0 miles 189° (S)	Sample Days (64)	59.6 ± 4.7	51.4 ± 4.4	39.8 ± 4.8	46.2 ± 4.2	67.5 ± 3.4	1016.8 ± 1.8	7.3 ± 0.7
		2013	60.2 ± 1.9	51.9 ± 1.8	40.4 ± 2.0	46.8 ± 1.7	67.9 ± 1.5	1017.0 ± 0.8	7.2 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 23-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 23-3 is the 95 percent confidence interval for each parameter. As shown in Table 23-3, average meteorological conditions on sample days are representative of average weather conditions experienced throughout the year near PRRI.

23.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at T.F. Green Airport near PRRI were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

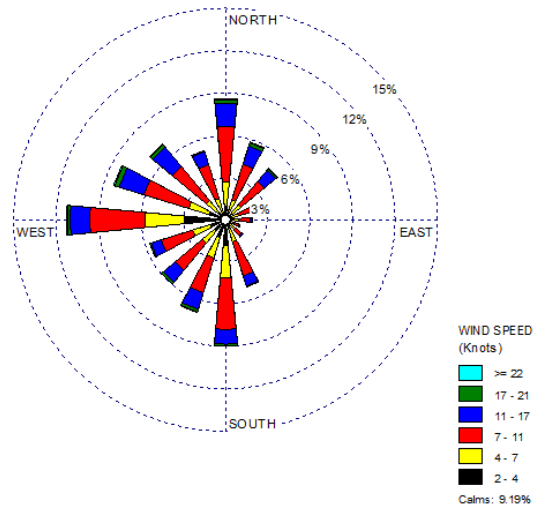
Figure 23-3 presents a map showing the distance between the weather station and PRRI, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 23-3 also presents three different wind roses for the PRRI monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 23-3. Wind Roses for the T.F. Green State Airport Weather Station near PRRI

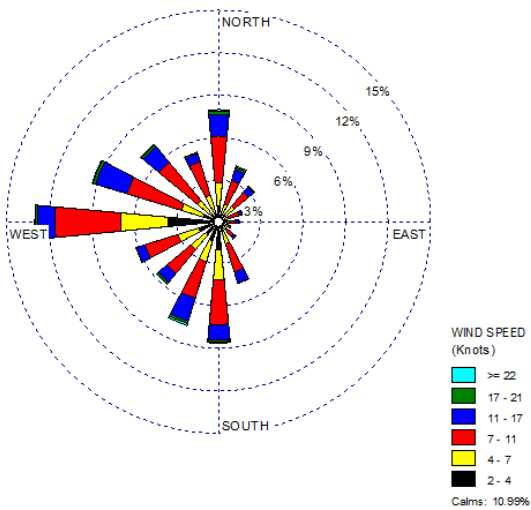
Location of PRRI and Weather Station



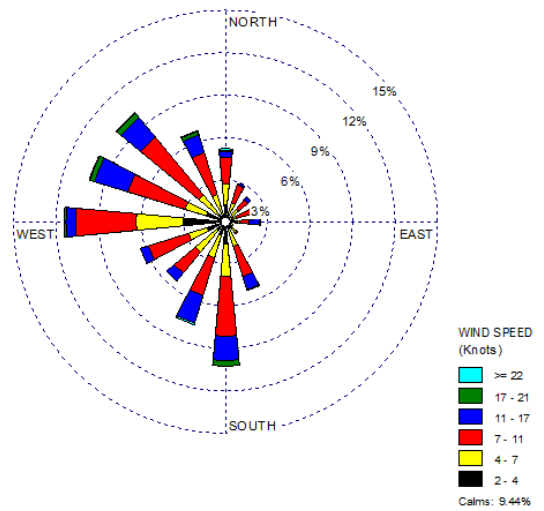
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 23-3 for PRRI include the following:

- The weather station at T.F. Green Airport is located 6 miles south of PRRI.
- The historical wind rose shows that westerly winds were observed most, accounting for approximately 11 percent of observations. Winds from the western quadrants, due north, and due south were often observed near PRRI while wind from the east-northeast to southeast were infrequently observed. Calm winds (those less than or equal to 2 knots) account for less than 10 percent of the hourly measurements.
- The wind patterns shown on the 2013 wind rose are similar to the historical wind patterns, as winds from the western quadrants, due north, and due south were observed most often. Westerly winds prevailed near PRRI in 2013, accounting for 13 percent of observations. The calm rate for 2013 is 11 percent, which is slightly higher than the calm rate for the historical wind rose.
- The wind patterns shown on the sample day wind rose continue the prevalence of winds from the western quadrants and due south, but the number of wind observations from the north is reduced. There are also fewer observations from the north-northeast and northeast. There is also a higher number of winds observations from the northwest, such that winds from the west to northwest account for nearly one-third of the wind observations on sample days near PRRI.

23.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for PRRI in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 23-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 23-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. PAHs and hexavalent chromium were sampled for at PRRI, although hexavalent chromium sampling was discontinued at the end of June.

Table 23-4. Risk-Based Screening Results for the Rhode Island Monitoring Site

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Providence, Rhode Island - PRRI						
Naphthalene	0.029	54	59	91.53	96.43	96.43
Benzo(a)pyrene	0.00057	1	58	1.72	1.79	98.21
Hexavalent Chromium	0.000083	1	12	8.33	1.79	100.00
Total		56	129	43.41		

Observations from Table 23-4 include the following:

- Three pollutants failed at least one screen for PRRI; 43 percent of concentrations for these three pollutants were greater than their associated risk screening value (or failed screens).
- Concentrations of naphthalene failed 54 of the 59 screens, with benzo(a)pyrene and hexavalent chromium failing one screen each.
- Naphthalene accounted for 96 percent of the total failed screens for PRRI. Thus, naphthalene is the only pollutant of interest for PRRI.

23.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Rhode Island monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically to illustrate how each site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at PRRI are provided in Appendices M and O.

23.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Rhode Island site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for PRRI are presented in Table 23-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 23-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Rhode Island Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
Providence, Rhode Island - PRRI						
Naphthalene	59/59	67.85 ± 26.22	53.83 ± 12.14	53.11 ± 11.81	70.74 ± 23.93	61.57 ± 9.53

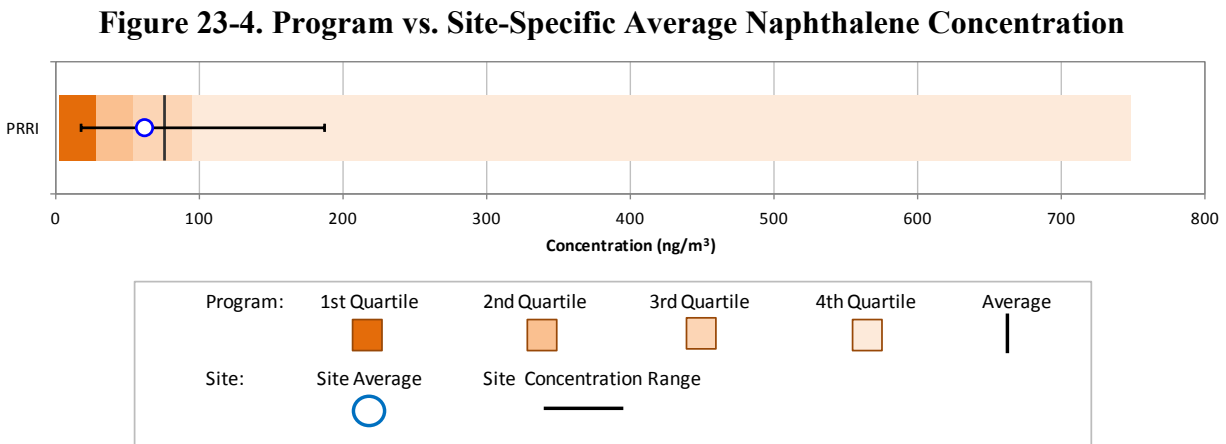
Observations for PRRI from Table 23-5 include the following:

- Naphthalene was detected in all of the valid PAH samples collected at PRRI.
- Concentrations of naphthalene measured at PRRI span an order of magnitude, ranging from 17.5 ng/m³ to 187 ng/m³.
- The second and third quarter average concentrations of naphthalene are very similar to each other.
- The first and fourth quarter average concentrations are also similar to each other and are slightly higher than the quarterly averages for the warmer months (although not significantly so), and exhibit more variability. Both the minimum and maximum naphthalene concentrations were measured at PRRI in November. Of the eight naphthalene concentrations greater than 100 ng/m³, four were measured during the

first quarter and two were measured during the fourth quarter (with one each measured during the other two calendar quarters).

23.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, a box plot was created for the pollutant shaded in gray in Table 23-4 for PRRI. Figure 23-4 overlays PRRI's minimum, annual average, and maximum naphthalene concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.



Observations from Figure 23-4 include the following:

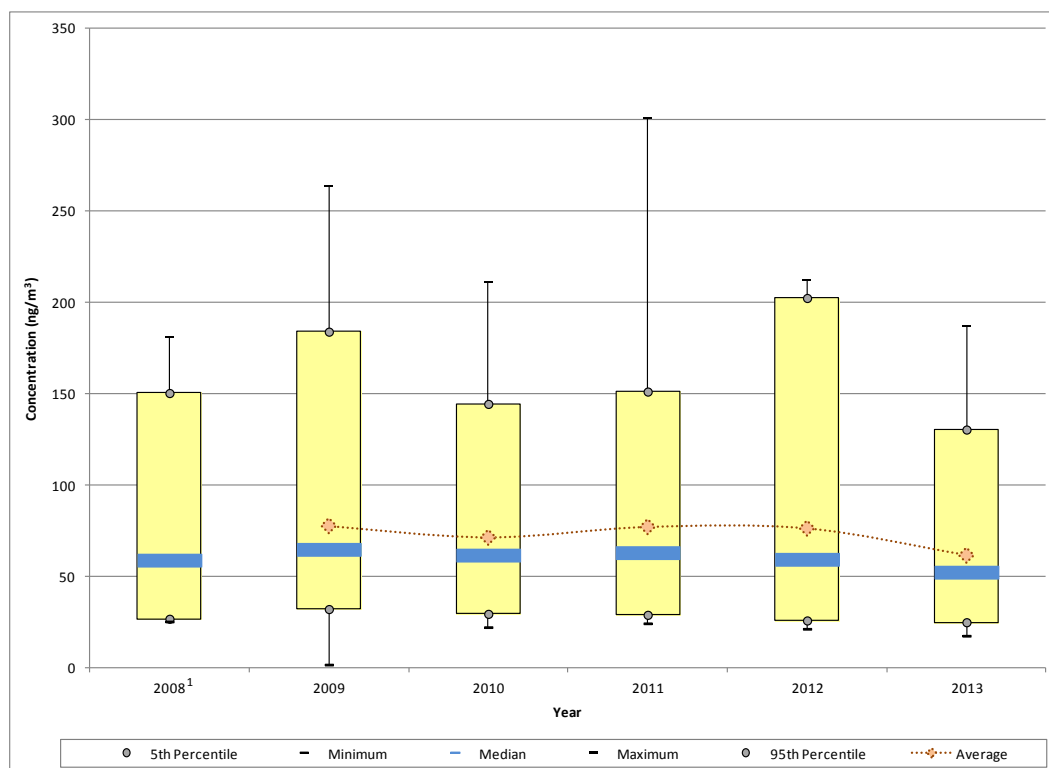
- The maximum naphthalene concentration measured at PRRI is one-fourth the maximum concentration measured at the program-level. There were no non-detects of naphthalene measured at PRRI (or across the program). The annual average naphthalene concentration for PRRI falls between the program-level median and average concentrations. PRRI's annual average concentration of naphthalene is in the middle of the range compared to other NMP sites sampling PAHs.

23.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. PRRI has sampled PAHs under the NMP since 2008. Thus, Figure 23-5 presents the 1-year statistical metrics for the pollutant of interest for PRRI. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a

minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 23-5. Yearly Statistical Metrics for Naphthalene Concentrations Measured at PRRI



¹ A 1-year average is not presented because sampling under the NMP did not begin until July 2008.

Observations from Figure 23-5 for naphthalene measurements collected at PRRI include the following:

- PRRI began sampling PAHs under the NMP in July 2008. Because a full year's worth of data is not available, a 1-year average concentration is not presented for 2008, although the range of measurements is provided.
- The maximum naphthalene concentration was measured at PRRI in 2011 (301 ng/m³). In total, 10 naphthalene concentrations greater than 200 ng/m³ have been measured at PRRI, of which seven were measured in November of any given year. In fact, the maximum concentration for all years except 2008 was measured in November. Of the 61 naphthalene concentrations greater than 100 ng/m³ measured at PRRI, more than half were measured during the fourth quarter of any given year.

- Although the range of concentrations measured has varied between 2009 and 2012, the 1-year average concentrations of naphthalene exhibit little variability, ranging from 71.39 ng/m³ (2010) to 77.73 ng/m³ (2009). This is also true for the median concentration, which ranges from 59.35 ng/m³ (2012) to 64.80 ng/m³ (2009).
- Several of the statistical parameters, including the 1-year average and median concentrations (61.57 ng/m³ and 52.30 ng/m³, respectively), are at a minimum for 2013.

23.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the PRRI monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

23.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Rhode Island monitoring site and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 23-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 23-6. Risk Approximations for the Rhode Island Monitoring Site

Pollutant	Cancer URE (µg/m ³) ⁻¹	Noncancer RfC (mg/m ³)	# of Measured Detections vs. # of Samples	Annual Average (ng/m ³)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Providence, Rhode Island - PRRI						
Naphthalene	0.000034	0.003	59/59	61.57 ± 9.53	2.09	0.02

Observations for PRRI from Table 23-6 include the following:

- Naphthalene has both a cancer URE and a noncancer RfC.
- The cancer risk approximation for naphthalene is 2.09 in-a-million.
- The noncancer hazard approximation for naphthalene is negligible (0.02 in-a-million), indicating that no adverse noncancer health effects are expected from this individual pollutant.

23.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 23-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 23-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 23-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for PRRI, as presented in Table 23-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 23-7. Table 23-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on the site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 23.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 23-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Rhode Island Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Providence, Rhode Island (Providence County) - PRRI					
Benzene	196.93	Formaldehyde	1.89E-03	Naphthalene	2.09
Formaldehyde	145.48	Benzene	1.54E-03		
Ethylbenzene	94.74	1,3-Butadiene	9.40E-04		
Acetaldehyde	76.01	Naphthalene	5.27E-04		
1,3-Butadiene	31.32	POM, Group 2b	4.00E-04		
Tetrachloroethylene	17.48	POM, Group 2d	2.39E-04		
Naphthalene	15.50	Ethylbenzene	2.37E-04		
Trichloroethylene	6.49	POM, Group 5a	2.30E-04		
POM, Group 2b	4.54	Arsenic, PM	1.83E-04		
Dichloromethane	4.12	Acetaldehyde	1.67E-04		

Table 23-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Rhode Island Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Providence, Rhode Island (Providence County) - PRRI					
Toluene	636.76	Acrolein	336,121.99	Naphthalene	0.02
Xylenes	390.67	1,3-Butadiene	15,660.35		
Methanol	386.43	Formaldehyde	14,844.73		
Hexane	324.64	Acetaldehyde	8,445.40		
Benzene	196.93	Benzene	6,564.42		
Formaldehyde	145.48	Naphthalene	5,167.59		
Ethylene glycol	130.02	Xylenes	3,906.66		
Ethylbenzene	94.74	Nickel, PM	3,332.59		
Acetaldehyde	76.01	Trichloroethylene	3,243.04		
Methyl isobutyl ketone	41.59	Arsenic, PM	2,840.49		

Observations from Table 23-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Providence County.
- Formaldehyde is the pollutant with the highest toxicity-weighted emissions (of the pollutants with cancer UREs), followed by benzene and 1,3-butadiene.
- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Providence County.
- Naphthalene, which is the only pollutant of interest for PRRI, has the seventh highest emissions and the fourth highest toxicity-weighted emissions for Providence County.
- Several POM Groups appear among the pollutants with the highest toxicity-weighted emissions for Providence County. POM, Groups 2b and 2d rank fifth and sixth for their toxicity-weighted emissions, respectively and POM, Group 2b also ranks ninth for its quantity emitted. POM, Groups 2b and 2d include several PAHs sampled for at PRRI, although none of these pollutants failed screens.
- POM, Group 5a ranks eighth for toxicity-weighted emissions. POM, Group 5a includes benzo(a)pyrene, which failed a single screen for PRRI. POM, Group 5a is not among the highest emitted “pollutants” in Providence County.

Observations from Table 23-8 include the following:

- Toluene, xylenes, and methanol are the highest emitted pollutants with noncancer RfCs in Providence County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, 1,3-butadiene, and formaldehyde.
- Four of the highest emitted pollutants in Providence County also have the highest toxicity-weighted emissions.
- Although naphthalene ranks sixth among the pollutants with the highest toxicity-weighted emissions, it is not one of the highest emitted pollutants (with a noncancer RfC) in Providence County (it ranks 15th).

23.6 Summary of the 2013 Monitoring Data for PRRI

Results from several of the data treatments described in this section include the following:

- ❖ *Three pollutants failed at least one screen for PRRI, with concentrations of naphthalene accounting for more than 95 percent of the failed screens. As such, naphthalene is PRRI’s only pollutant of interest.*

- *Concentrations of naphthalene measured at PRRI span an order of magnitude, ranging from 17.5 ng/m³ to 187 ng/m³.*
- *The highest concentrations of naphthalene measured at PRRI tended to be measured during the fourth quarter of the year, based on data collected since sampling commenced in 2008.*

24.0 Site in South Carolina

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in South Carolina, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

24.1 Site Characterization

This section characterizes the South Carolina monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

CHSC is located in central Chesterfield County, South Carolina. Figure 24-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 24-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 24-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 24-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 24-1. Chesterfield, South Carolina (CHSC) Monitoring Site

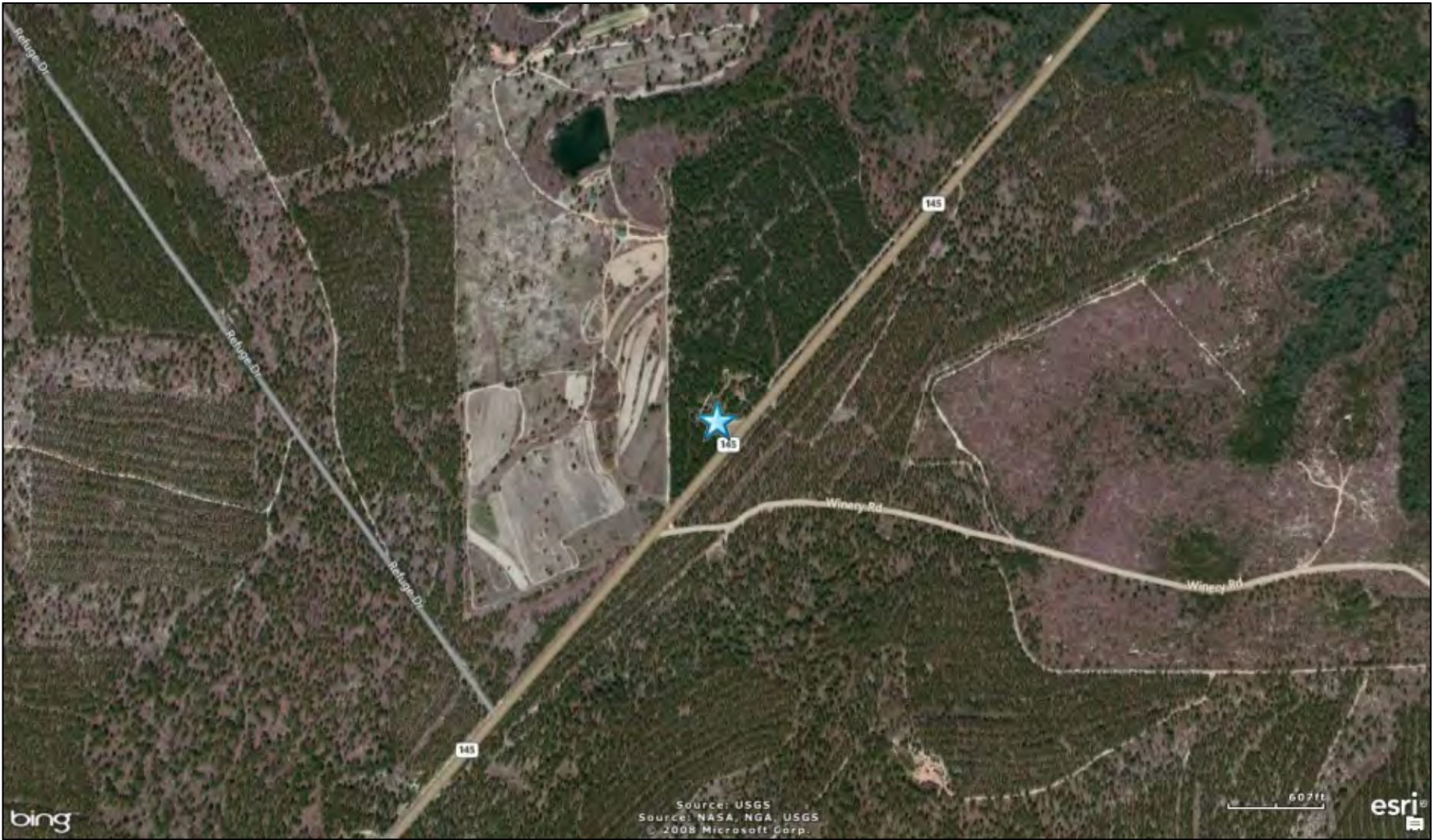


Figure 24-2. NEI Point Sources Located Within 10 Miles of CHSC

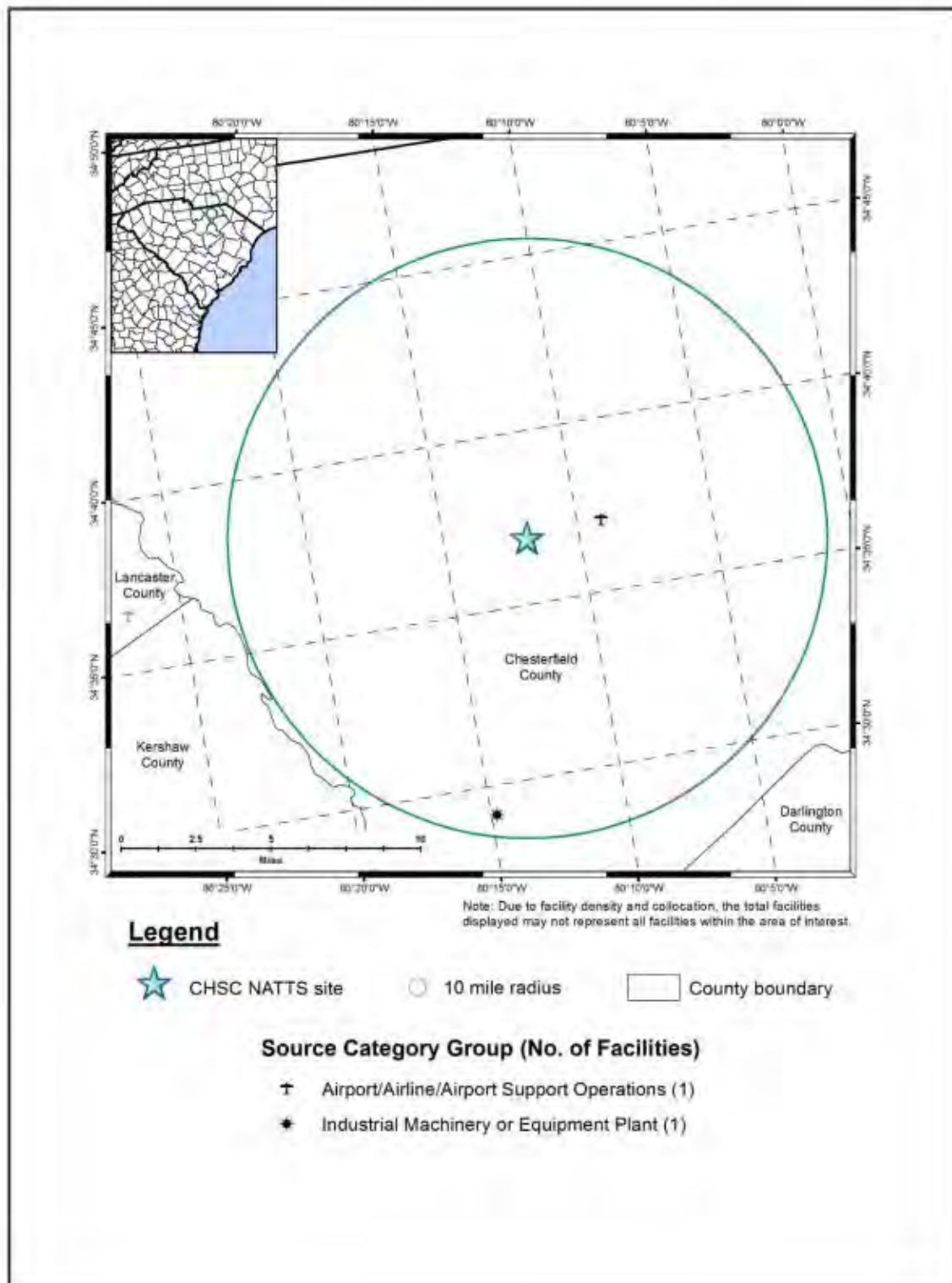


Table 24-1. Geographical Information for the South Carolina Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>CHSC</i>	45-025-0001	Not in a city	Chesterfield	None	34.615367, -80.198787	Forest	Rural	VOCs, Carbonyl Compounds, O ₃ , Meteorological parameters, PM ₁₀ , PM ₁₀ Speciation, PM _{2.5} , PM _{2.5} Speciation, Black Carbon, IMPROVE Speciation.

¹ Data for additional pollutants are reported to AQS for CHSC (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

CHSC is located about 14 miles south of the North Carolina/South Carolina border, about halfway between the towns of McBee and Chesterfield. The monitoring site is located near the Ruby fire tower and, as Figure 24-1 shows, is located just off State Highway 145. The surrounding area is rural in nature and is part of the Carolina Sandhills National Wildlife Refuge. Figure 24-2 shows that few point sources are located within 10 miles of CHSC, the closest of which is the Wild Irish Rose Airport.

Table 24-2 presents additional site-characterizing information, including indicators of mobile source activity, for the South Carolina monitoring site. Table 24-2 includes both county-level population and vehicle registration information. Table 24-2 also contains traffic volume information for CHSC as well as the location for which the traffic volume was obtained. Additionally, Table 24-2 presents the daily VMT for Chesterfield County.

Table 24-2. Population, Motor Vehicle, and Traffic Information for the South Carolina Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
<i>CHSC</i>	Chesterfield	46,197	41,728	700	Hwy 145 between US-1 and Hwy 109	1,265,439

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2013 data (SC DMV, 2013)

³AADT reflects 2013 data (SC DOT, 2013)

⁴County-level VMT reflects 2013 data (SC DOT, 2014)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 24-2 include the following:

- Chesterfield County's population is among the lowest compared to other counties with NMP sites, ranking fourth lowest. This is also true for the county-level vehicle ownership for Chesterfield County, which is the sixth lowest among NMP sites.
- The traffic volume experienced near CHSC is the second lowest compared to other NMP monitoring sites. The traffic estimate provided is for State Highway 145 between State Highway 109 and US-1.
- The daily VMT for Chesterfield County is among the lowest VMT compared to other counties with NMP sites, ranking fifth lowest.

24.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in South Carolina on sample days, as well as over the course of the year.

24.2.1 Climate Summary

Chesterfield County is located along the North Carolina/South Carolina border, about 35 miles northwest of the city of Florence. Although the area experiences all four seasons, South Carolina's southeastern location ensures mild winters and long, hot summers. Summers are dominated by the Bermuda high pressure system over the Atlantic Ocean, which allows southwesterly winds to prevail, bringing in warm, moist air out of the Gulf of Mexico. During winter, winds out of the southwest shift northeasterly after frontal systems move across the area. The mountains to the northwest help shield the area from cold air outbreaks. More than 2 inches of precipitation can be expected any given month, with the maximum typically occurring in July and the minimum occurring during the fall months. Chesterfield County leads the state in the average number of sleet and freezing rain events per year (Bair, 1992; SC SCO, 2015).

24.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the South Carolina monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station with adequate data is located at the Richmond County Airport in Rockingham, North Carolina (WBAN 03738). Additional information about the Richmond County Airport weather station, such as the distance between the site and the weather station, is provided in Table 24-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 24-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), and wind (average scalar wind speed) information for days samples were collected and for all of 2013 (sea level pressure was not recorded at the Richmond County Airport). Also included in Table 24-3 is the 95 percent confidence interval for each parameter. As shown in Table 24-3, average meteorological conditions experienced on sample days were representative of average weather conditions experienced throughout the year near CHSC. The largest difference is shown for relative humidity, although the difference is not statistically significant.

Table 24-3. Average Meteorological Conditions near the South Carolina Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Chesterfield, South Carolina - CHSC									
Richmond County Airport 03738 (34.89, -79.76)	34.9 miles	Sample Days (61)	71.6 ± 3.7	61.8 ± 3.6	51.3 ± 4.4	56.3 ± 3.7	72.1 ± 3.6	NA	4.1 ± 0.5
	53° (NE)	2013	71.2 ± 1.5	61.5 ± 1.5	51.5 ± 1.7	56.2 ± 1.5	73.3 ± 1.4	NA	4.2 ± 0.2

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA= Sea level pressure was not recorded at the Richmond County Airport.

24.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at Richmond County Airport near CHSC were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 24-3 presents a map showing the distance between the weather station and CHSC, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 24-3 also presents three different wind roses for the CHSC monitoring site. First, a historical wind rose representing 2005 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 24-3 for CHSC include the following:

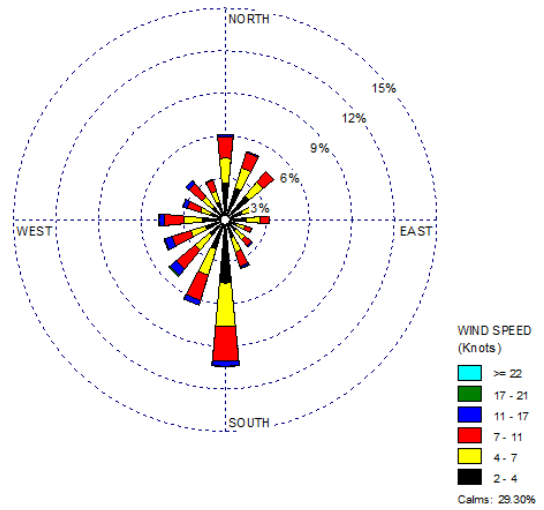
- The Richmond County Airport weather station is located across the North Carolina/South Carolina border, approximately 31 miles northeast of CHSC.
- The historical wind rose for CHSC shows that calm winds (those less than or equal to 2 knots) account for nearly 30 percent of the hourly measurements. For wind speeds greater than 2 knots, winds from the south are most common, accounting for 10 percent of observations. Winds from the southwest and northeast quadrants (including north) are also observed frequently, while winds from the northwest and southeast quadrants are infrequently observed.
- The wind patterns shown on the 2013 wind rose for CHSC are similar to the historical wind patterns, indicating that wind conditions in 2013 were similar to what is expected climatologically near this site, although there was a slightly higher percentage of winds observations from the north to northeast.
- The sample day wind rose shows that southerly winds were still prevalent on sample days. Northerly winds were also observed frequently, while slightly fewer north-northeasterly were observed.

Figure 24-3. Wind Roses for the Richmond County Airport Weather Station near CHSC

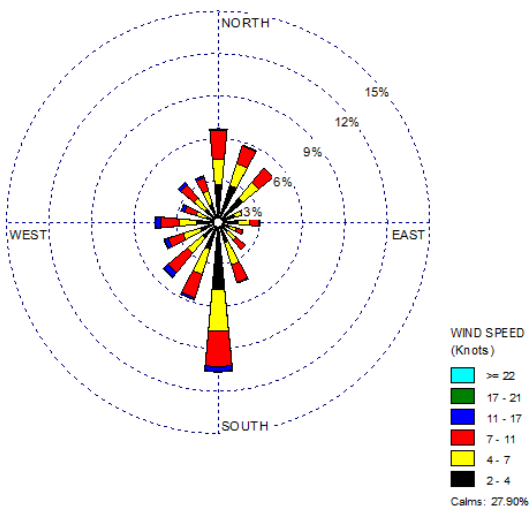
Location of CHSC and Weather Station



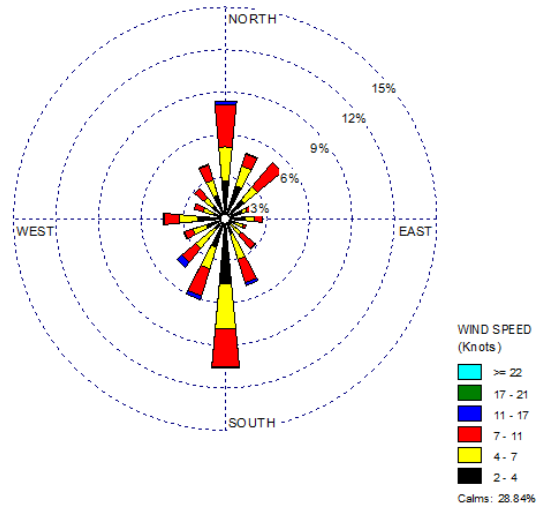
2005-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



24.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for CHSC in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 24-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 24-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Hexavalent chromium and PAHs were sampled for at CHSC, although hexavalent chromium sampling was discontinued in June.

Table 24-4. Risk-Based Screening Results for the South Carolina Monitoring Site

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Chesterfield, South Carolina - CHSC						
Naphthalene	0.029	2	58	3.45	100.00	100.00
Total		2	58	3.45		

Observations from Table 24-4 include the following:

- Naphthalene was the only pollutant to fail screens for CHSC.
- This pollutant was detected in all 58 valid samples collected at CHSC and failed two screens, or approximately 3 percent of screens.
- This site has the second lowest number of failed screens (2) among NMP sites (excluding the four NMP sites with no pollutants failing screens).

24.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the South Carolina monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.

- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at CHSC are provided in Appendices M and O.

24.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the South Carolina site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the pollutants of interest for CHSC are presented in Table 24-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 24-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the South Carolina Monitoring Site

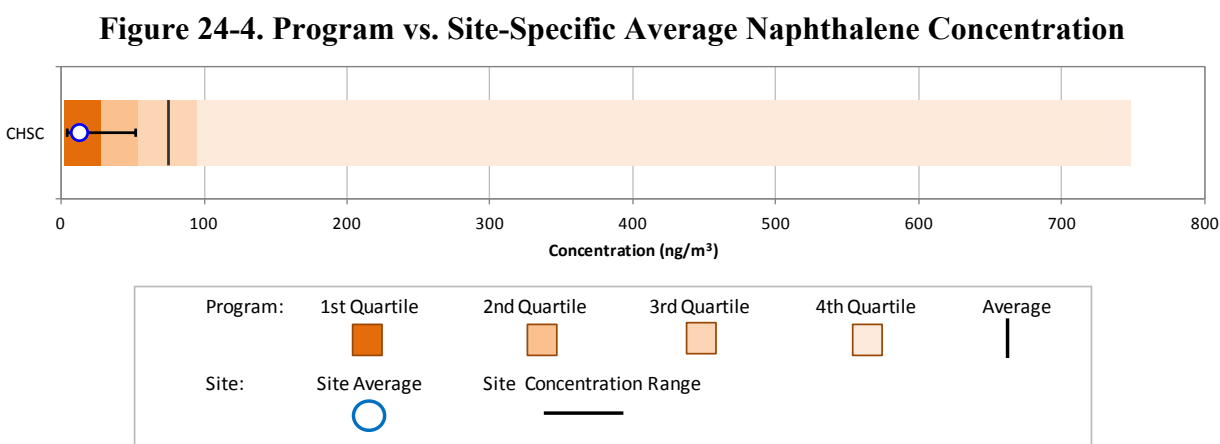
Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
Chesterfield, South Carolina - CHSC						
Naphthalene	58/58	19.69 ± 8.57	10.81 ± 3.31	10.38 ± 2.78	10.80 ± 1.97	12.69 ± 2.33

Observations for CHSC from Table 24-5 include the following:

- Naphthalene concentrations measured at CHSC span an order of magnitude, ranging from 4.46 ng/m³ to 51.8 ng/m³, with a median concentration of 10.25 ng/m³.
- The annual average concentration of naphthalene is 12.69 ± 2.33 ng/m³. This is the second lowest annual average concentration of naphthalene among NMP sites sampling PAHs.
- The first quarter average concentration of naphthalene (19.69 ± 8.57 ng/m³) is higher than the other quarterly averages and has a relatively large confidence interval associated with it, while the other quarterly averages fall between 10 ng/m³ and 11 ng/m³. The two highest naphthalene concentrations are both around 50 ng/m³ and were measured at CHSC in January. All other naphthalene concentrations measured at CHSC were less than 30 ng/m³. Four of the six naphthalene concentrations greater than 20 ng/m³ were measured during the first quarter of 2013.

24.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, a box plot was created for the pollutant shaded in gray in Table 24-4 for CHSC. Figure 24-4 overlays the site's minimum, annual average, and maximum naphthalene concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations of naphthalene, as described in Section 3.4.3.1.



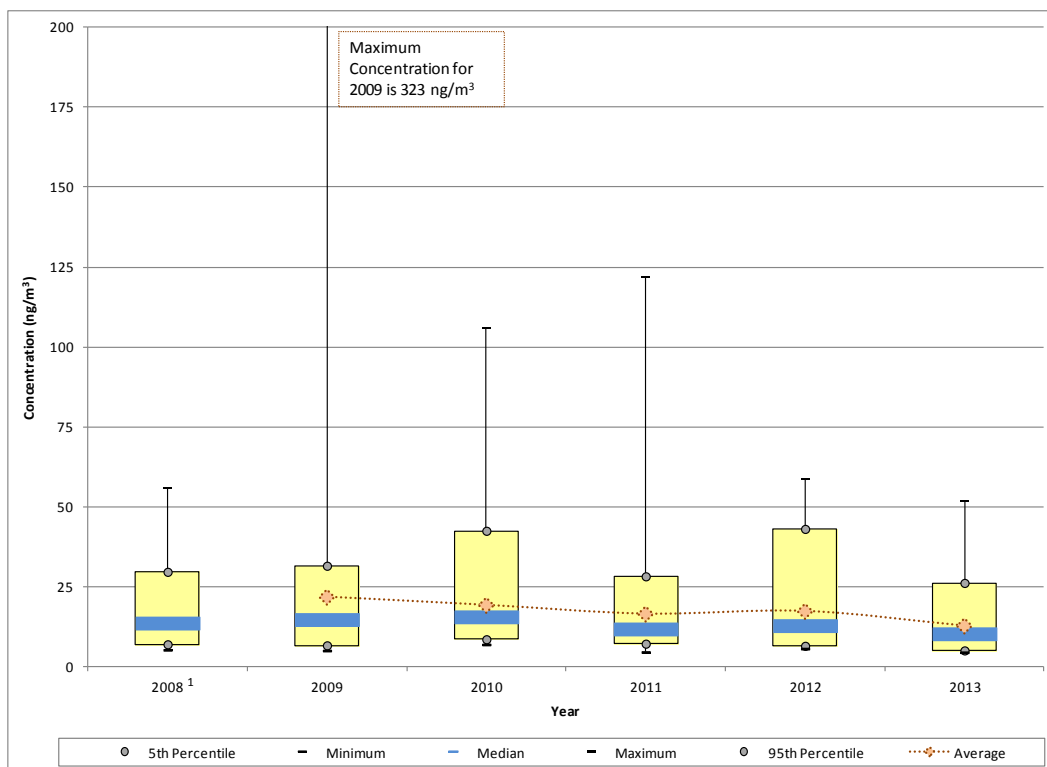
Observations from Figure 24-4 include the following:

- All of the naphthalene measurements collected at CHSC are less than the median naphthalene concentration at the program-level. The annual average concentration of naphthalene for CHSC is less than the program-level first quartile and roughly one-sixth the program-level average concentration. There were no non-detects of naphthalene measured at CHSC or across the program.

24.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. CHSC has sampled PAHs under the NMP since 2008. Thus, Figure 24-5 presents the 1-year statistical metrics for the pollutant of interest for CHSC. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 24-5. Yearly Statistical Metrics for Naphthalene Concentrations Measured at CHSC



¹ A 1-year average is not presented because sampling under the NMP did not begin until March 2008.

Observations from Figure 24-5 for naphthalene measurements collected at CHSC include the following:

- CHSC began sampling PAHs under the NMP in late March 2008. Because a full year's worth of data is not available, a 1-year average concentration is not presented for 2008, although the range of measurements is provided.
- The maximum concentration of naphthalene was measured on May 1, 2009 (323 ng/m³). This is the only concentration of naphthalene greater than 200 ng/m³ measured at CHSC since the onset of PAH sampling. Only two measurements greater than 100 ng/m³ have been measured (one each in 2010 and 2011) and no other concentrations greater than 60 ng/m³ have been measured at this site.
- The 1-year average concentration of naphthalene has a slight overall decreasing trend over the period of sampling, although the confidence intervals calculated for CHSC's 1-year averages are relatively large, particularly for 2009, when the outlier was measured.
- With the exception of 2012, the 1-year average concentration has decreased slightly each year, from 21.71 ng/m³ for 2009 to 12.69 ng/m³ for 2013. The slight bump in the 1-year average concentration for 2012 results from fewer concentrations at the lower end of the concentration range (the number of naphthalene concentrations less than 10 ng/m³ decreased from 21 to 16 from 2011 to 2012) and more concentrations at the upper end of the concentration range (the number of concentrations greater than 30 ng/m³ increased from three to seven).
- All of the statistical parameters shown in Figure 24-5 are at a minimum for 2013.

24.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the CHSC monitoring site. Refer to Sections 3.2, 3.4.3.3 and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

24.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the South Carolina monitoring site and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and

noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 24-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 24-6. Risk Approximations for the South Carolina Monitoring Site

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Chesterfield, South Carolina - CHSC						
Naphthalene	0.000034	0.003	58/58	12.69 ± 2.33	0.43	<0.01

Observations for CHSC from Table 24-6 include the following:

- Naphthalene has both a cancer URE and a noncancer RfC.
- The cancer risk approximation for naphthalene is less than 1 in-a-million (0.43 in-a-million).
- The noncancer hazard approximation for naphthalene is low (less than 0.01), indicating that no adverse noncancer health effects are expected from this individual pollutant.

24.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 24-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 24-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 24-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for CHSC, as presented in Table 24-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 24-7. Table 24-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 24-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the South Carolina Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Chesterfield, South Carolina (Chesterfield County) - CHSC					
Benzene	26.67	Formaldehyde	2.95E-04	Naphthalene	0.43
Formaldehyde	22.71	Benzene	2.08E-04		
Ethylbenzene	13.66	1,3-Butadiene	1.19E-04		
Acetaldehyde	12.77	Naphthalene	4.64E-05		
1,3-Butadiene	3.96	POM, Group 2b	3.48E-05		
Naphthalene	1.36	Ethylbenzene	3.42E-05		
POM, Group 2b	0.40	Arsenic, PM	3.20E-05		
POM, Group 2d	0.34	POM, Group 5a	3.01E-05		
Tetrachloroethylene	0.31	POM, Group 2d	2.95E-05		
Trichloroethylene	0.30	Acetaldehyde	2.81E-05		

Table 24-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the South Carolina Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Chesterfield, South Carolina (Chesterfield County) - CHSC					
Toluene	98.52	Acrolein	37,454.84	Naphthalene	<0.01
Xylenes	57.96	Formaldehyde	2,316.92		
Hexane	45.68	Cyanide Compounds, gas	2,002.83		
Methanol	30.61	1,3-Butadiene	1,978.47		
Benzene	26.67	Acetaldehyde	1,419.39		
Formaldehyde	22.71	Benzene	888.84		
Ethylene glycol	16.72	Xylenes	579.57		
Ethylbenzene	13.66	Lead, PM	568.45		
Acetaldehyde	12.77	Arsenic, PM	495.85		
Methyl isobutyl ketone	4.44	Naphthalene	454.80		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 24.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 24-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Chesterfield County.
- Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Chesterfield County.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Chesterfield County.
- Naphthalene, the only pollutant of interest for CHSC, appears on both emissions-based lists, with the sixth highest emissions and the fourth highest toxicity-weighted emissions for Chesterfield County.
- Several POM Groups appear among the pollutants with the highest emissions and toxicity-weighted emissions. POM, Group 2b appears on both emissions-based lists and includes several PAHs sampled for at CHSC including acenaphthylene, fluoranthene, and perylene. POM, Group 2d, which includes phenanthrene and pyrene, also appears on both emissions-based lists. POM, Group 5a, which includes benzo(a)pyrene, ranks eighth for its toxicity weighted emissions but is not among the highest emitted. None of the pollutants sampled for at CHSC and included in POM, Groups 2b, 2d, or 5a failed screens for CHSC.

Observations from Table 24-8 include the following:

- Toluene, xylenes, and hexane are the highest emitted pollutants with noncancer RfCs in Chesterfield County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and cyanide compounds (gaseous).

- Four of the highest emitted pollutants in Chesterfield County also have the highest toxicity-weighted emissions.
- Naphthalene ranks 10th for its toxicity-weighted emissions but does not appear among the highest emitted pollutants in Chesterfield County (of the pollutants with noncancer RfCs).

24.6 Summary of the 2013 Monitoring Data for CHSC

Results from several of the data treatments described in this section include the following:

- ❖ *Naphthalene was the only pollutant to fail screens for CHSC. This site has the second lowest number of failed screens among NMP sites.*
- ❖ *CHSC has the second lowest annual average concentration of naphthalene among NMP sites sampling PAHs.*
- ❖ *Concentrations of naphthalene measured at CHSC in 2013 were the lowest since the onset of sampling in 2008.*

25.0 Sites in Texas

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS sites in Texas, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

25.1 Site Characterization

This section characterizes the CAMS 35 and CAMS 85 monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The CAMS 35 monitoring site is located in the Houston-The Woodlands-Sugarland, Texas CBSA and CAMS 85 is part of the Marshall, Texas CBSA. Figure 25-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 25-2 identifies nearby point source emissions locations by source category for the site, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 25-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Figures 25-3 and 25-4 are the composite satellite image and emissions sources map for CAMS 85. Table 25-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 25-1. Deer Park, Texas (CAMS 35) Monitoring Site

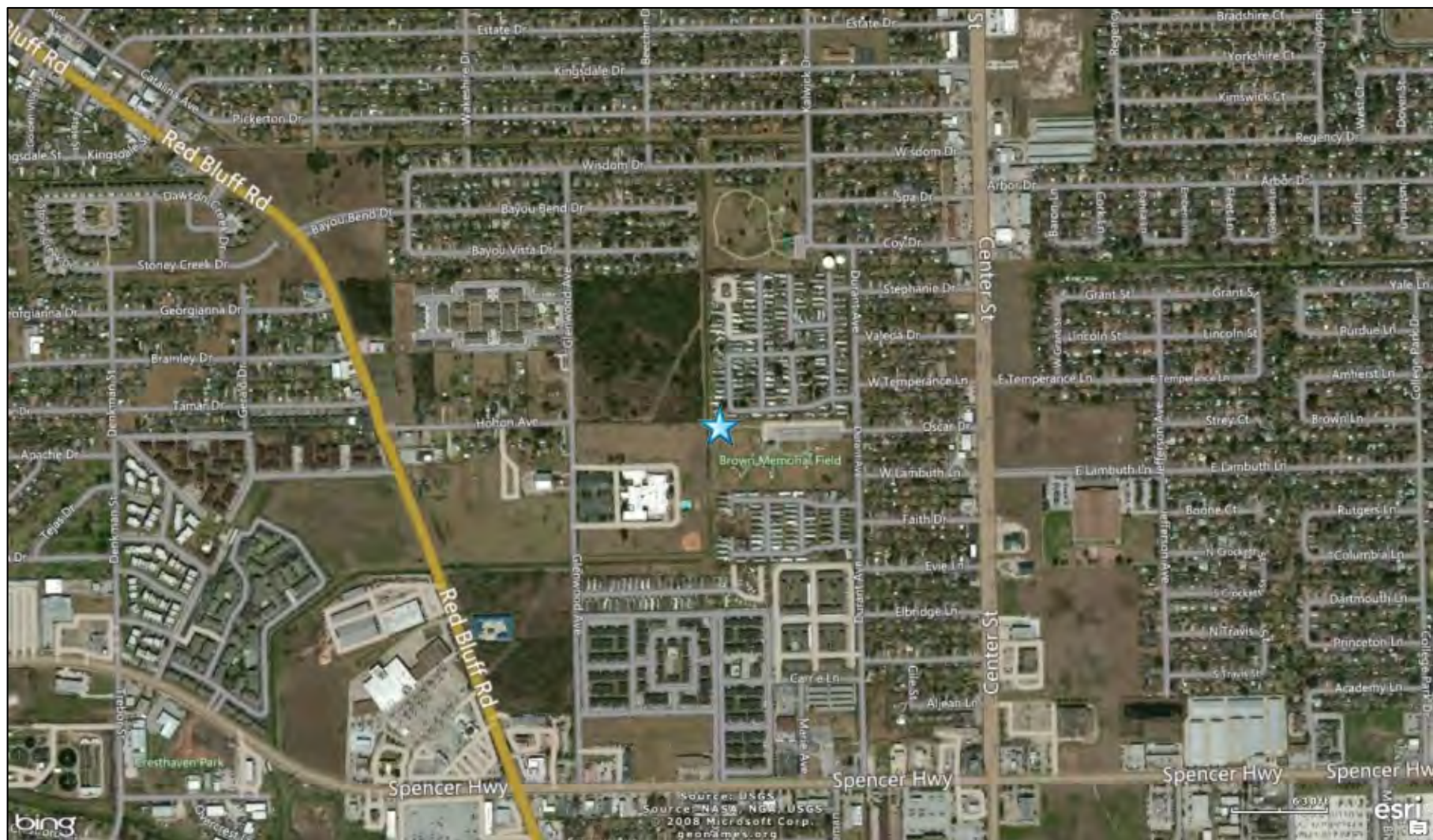


Figure 25-2. NEI Point Sources Located Within 10 Miles of CAMS 35

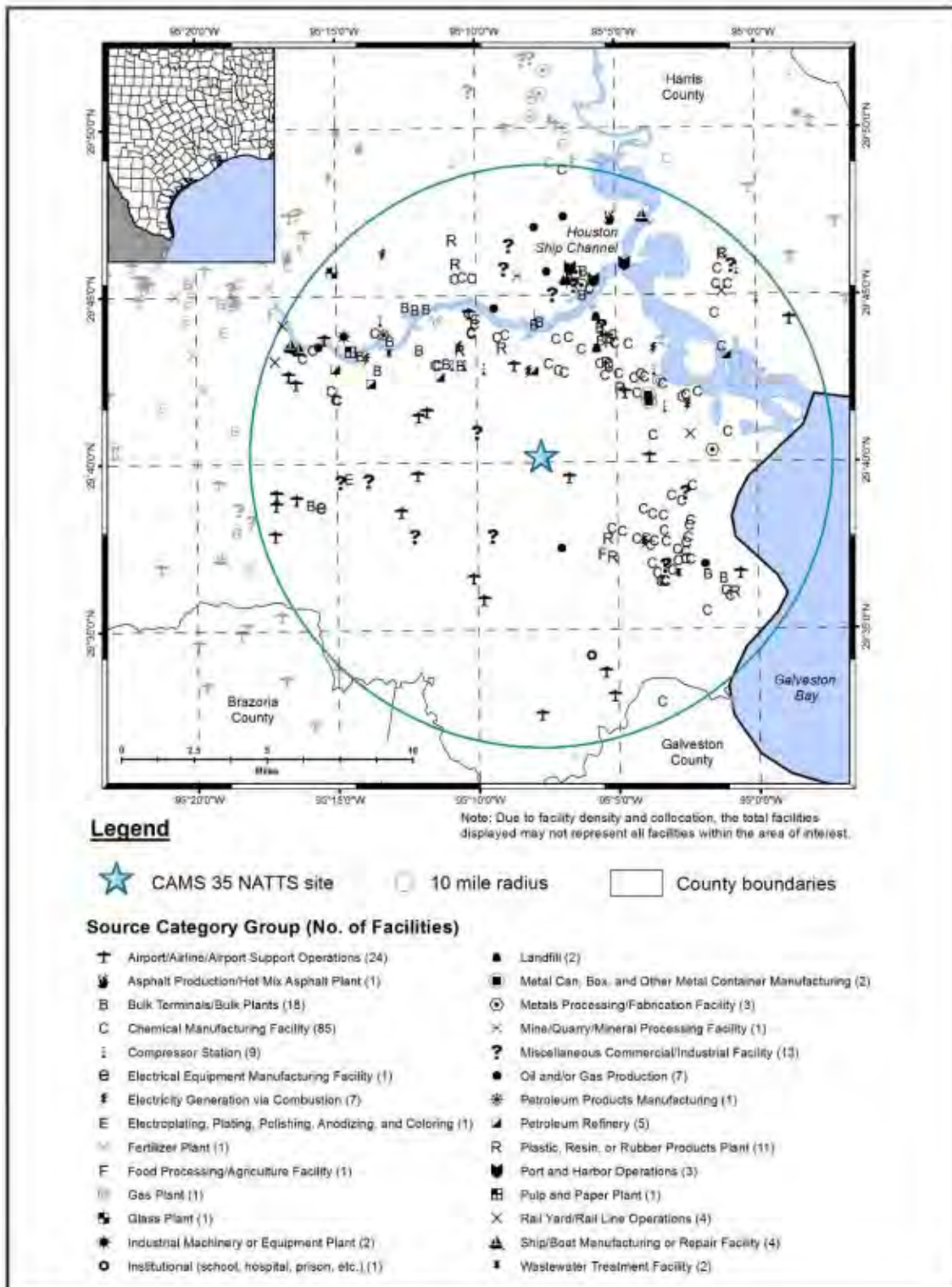


Figure 25-3. Karnack, Texas (CAMS 85) Monitoring Site

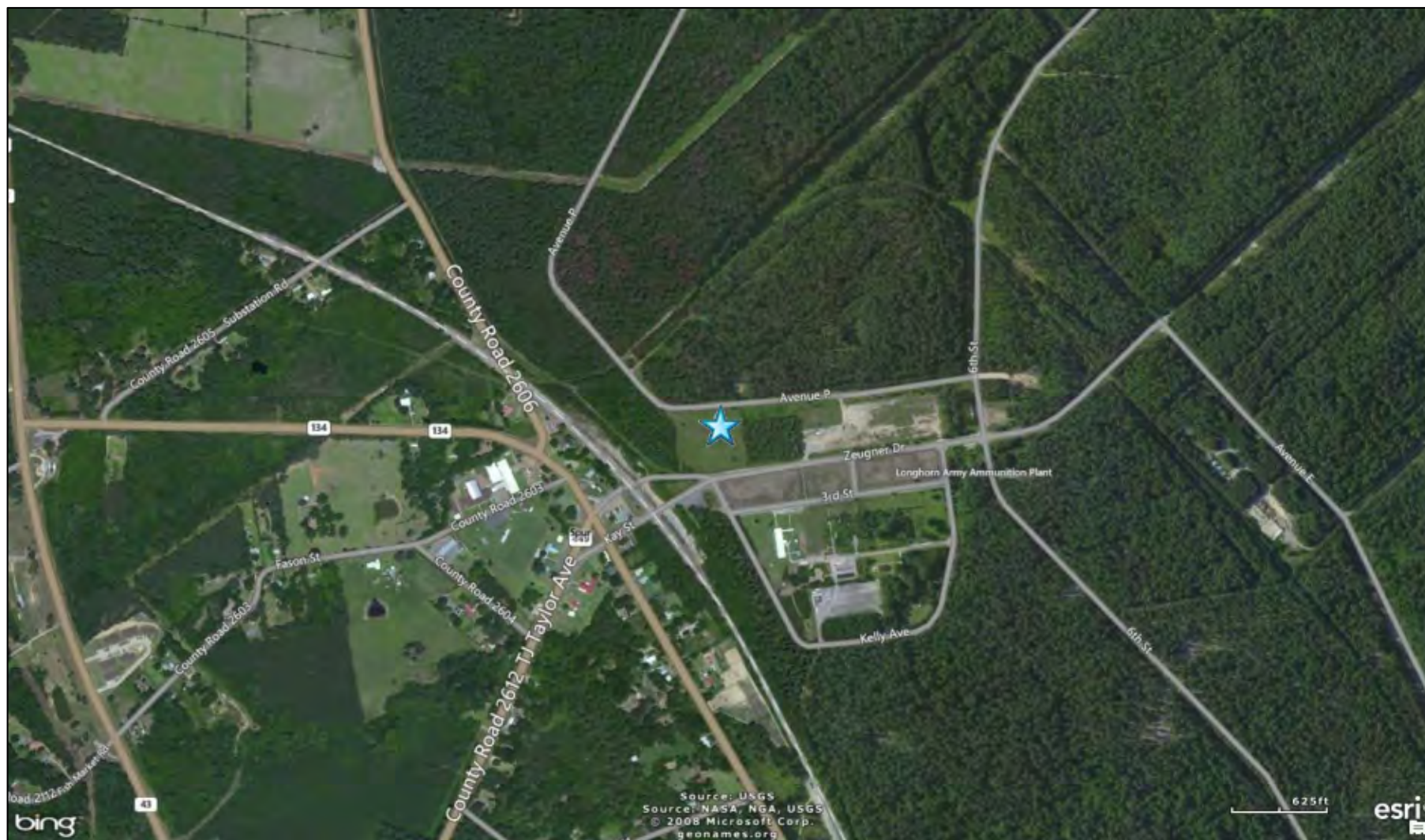


Figure 25-4. NEI Point Sources Located Within 10 Miles of CAMS 85

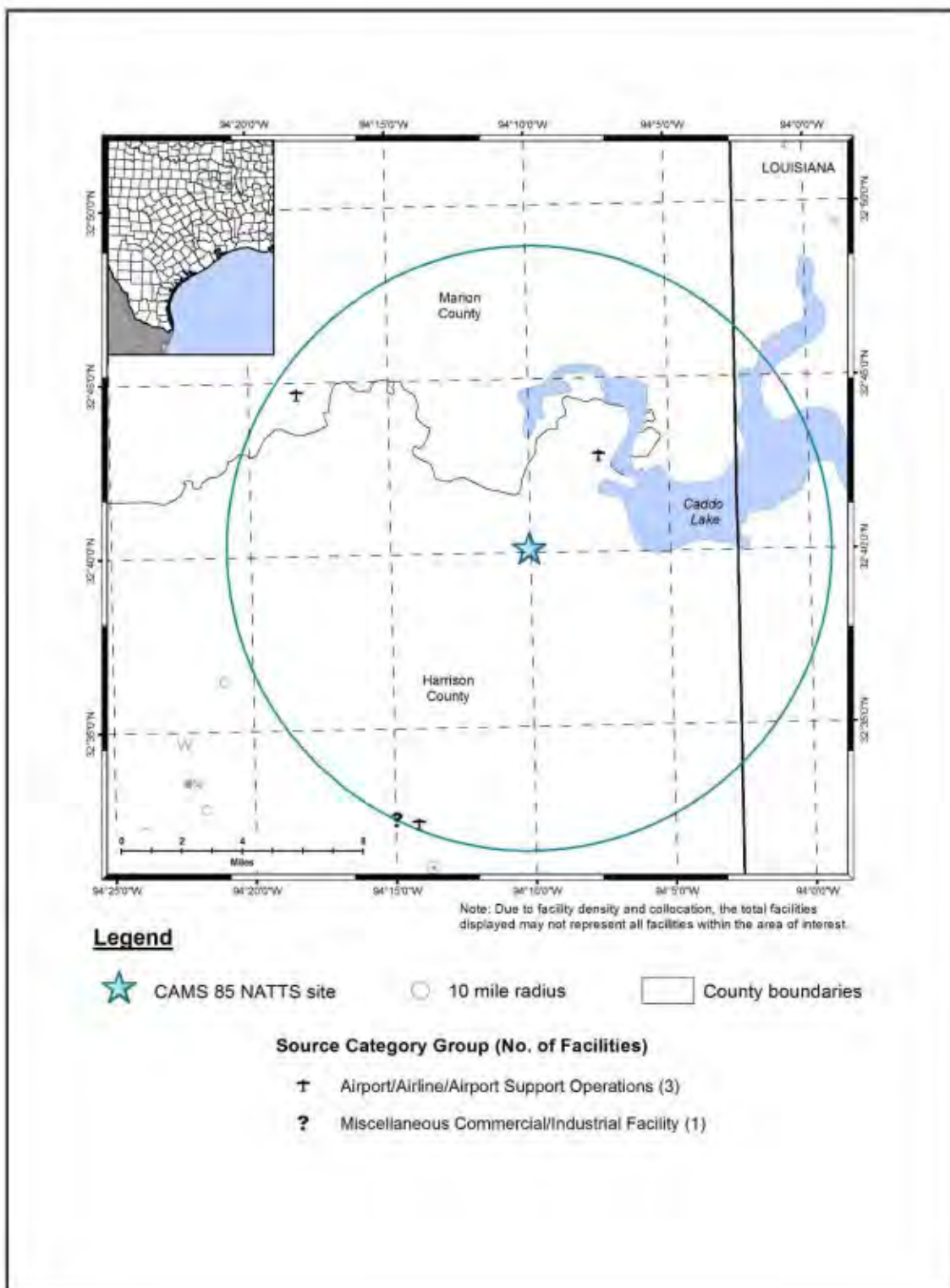


Table 25-1. Geographical Information for the Texas Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>CAMS 35</i>	48-201-1039	Deer Park	Harris	Houston-The Woodlands-Sugar Land, TX	29.670025, -95.128508	Residential	Urban/City Center	Haze, TSP Lead, CO, SO ₂ , NO _y , NO, NO ₂ , NO _x , PAMS/SNMOCs, VOCs, Carbonyl compounds, O ₃ , Meteorological parameters, PM ₁₀ , PM Coarse, PM ₁₀ Speciation, PM _{2.5} , PM _{2.5} Speciation, Black Carbon, IMPROVE Speciation, SVOCs.
<i>CAMS 85</i>	48-203-0002	Karnack	Harrison	Marshall, TX	32.668987, -94.167457	Agricultural	Rural	SVOCs, NO ₂ , NO, NO _x , PAMS/SNMOCs, Carbonyl Compounds, VOCs, O ₃ , Meteorological parameters, PM ₁₀ , PM ₁₀ Speciation, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The CAMS 35 monitoring site is located in Deer Park, southeast of Houston, in east Texas. This site serves as the Houston NATTS Site. The site is located at the Spencerview Athletic Complex (formerly Brown Memorial Field), a 10-acre park with several baseball fields (Deer Park, 2015). The surrounding area is primarily residential area, as shown in Figure 25-1. Beltway 8, a major thoroughfare around Houston, is located 1.6 miles to the west of CAMS 35. Galveston Bay is located to the east and southeast of the site and the Houston Ship Channel, which runs from the bay westward towards downtown Houston, is located roughly 4 miles to the north on the other side of Highway 225. The east side of Houston has significant industry, including several major oil refineries. As Figure 25-2 shows, a large number of emissions sources are located roughly along a line that runs east to west just north of the site (or along the Houston Ship Channel). A second cluster of emissions sources is located to the southeast of the monitoring site. The source category with the greatest number of sources (85) surrounding CAMS 35 is chemical manufacturing. Other source categories with a number of sources around CAMS 35 include the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; bulk terminals and bulk plants; and plastic, resin, or rubber products plants. The point source located closest to the CAMS 35 monitoring site is a heliport at San Jacinto College's Central Campus in Pasadena, just over 1 mile southeast of the site. There are no other point sources within 2 miles of CAMS 35.

The CAMS 85 NATTS site is located in Karnack, in northeast Texas. The monitoring site is about 12 miles northeast of Marshall, Texas and about 7 miles west of the Texas-Louisiana border. This site is located on the property of the former Longhorn Army Ammunition Plant near the intersection of FM Road 134 and Spur Road 449 (Taylor Avenue), as shown in Figure 25-3. The plant ceased manufacturing munitions in the late 1990s. The property was identified by EPA as a Superfund site in 1990. Ownership of the property was later transferred from the Army to the U.S. Fish and Wildlife Service, where the Caddo Lake National Wildlife Refuge was established (EPA, 2015g). The surrounding area is rural and agricultural. As Figure 25-4 shows, there are few point sources within 10 miles of CAMS 85 and most these sources all fall into the airport source category. The closest source to CAMS 85 is the Fly-N-Fish Lodge Airport near Caddo Lake.

Table 25-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Texas monitoring sites. Table 25-2 includes both county-level population and vehicle registration information. Table 25-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 25-2 presents the county-level daily VMT for Harris and Harrison Counties.

Table 25-2. Population, Motor Vehicle, and Traffic Information for the Texas Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
CAMS 35	Harris	4,336,853	3,401,957	31,043	Spencer Hwy, from Red Bluff Rd to Underwood Rd	56,245,209
CAMS 85	Harrison	66,886	72,689	1,250	FM 134 at Spur Road 449	2,511,619

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect 2013 data (TX DMV, 2014)

³AADT reflects 2004 data for CAMS 35 and 2012 data for CAMS 85 (HCPID, 2014 and TX DOT, 2013a)

⁴County-level VMT reflects 2013 data (TX DOT, 2013b)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 25-2 include the following:

- The population and vehicle ownership counts are significantly higher for CAMS 35 than CAMS 85. This is not surprising given the rural nature of the area surrounding the CAMS 85 site and the large urban area encompassed within Harris County.
- Compared to other counties with NMP monitoring sites, Harris County is third highest for both county-level population and county-level vehicle ownership. Conversely, Harrison County ranks on the low end for both county-level population and vehicle ownership.
- The traffic volume passing CAMS 35 is substantially higher than the traffic volume passing CAMS 85. The traffic volume for CAMS 35 is in the middle of the range compared to other NMP sites while the traffic volume near CAMS 85 is among the lower traffic volumes for NMP sites. Traffic data for CAMS 35 are provided for Spencer Highway between Red Bluff Road and Underwood Road; the traffic data for CAMS 85 are provided for FM Road 134 at the intersection with Spur Road 449.
- Like the other mobile source activity indicators, county-level daily VMT is considerably higher for Harris County than Harrison County. Harris County ranks fourth compared to other counties with NMP sites for VMT, while Harrison County ranks in the bottom third.

25.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Texas on sample days, as well as over the course of the year.

25.2.1 Climate Summary

The eastern third of Texas, where the CAMS 35 and CAMS 85 sites are located, is characterized by a subtropical humid climate, with the climate becoming more continental in nature farther north and west. The proximity to the Gulf of Mexico acts as a moderating influence as temperatures soar in the summer or dip in the winter. Areas closer to the coast, such as Houston, remain slightly cooler in the summer than neighboring areas to the north. The reverse is also true, as coastal areas are warmer in the winter than areas farther inland, although East Texas winters are relatively mild. The onshore flow from the Gulf of Mexico allows humidity levels to remain high in East Texas, particularly near the coast. The winds flow out of the Gulf of Mexico a majority of the year, with the winter months being the exception, as frontal systems allow colder air to filter in from the north. Abundant rainfall is also typical of the region, again due in part to the nearness to the Gulf of Mexico. Greater than 45 inches of precipitation can be expected annually. Severe weather is most common in spring, particularly in May, and tropical systems can be a threat to the state during the summer and fall. Snowfall is rare in East Texas but ice storms are more common in northeast Texas than in other parts of the state (Wood, 2004; TAMU, 2015; TWDR, 1983).

25.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the Texas monitoring sites (NCDC, 2013), as described in Section 3.4.2. The closest weather station to CAMS 35 is located at William P. Hobby Airport, WBAN 12918; the closest weather station to CAMS 85 is located at Shreveport Regional Airport, WBAN 13957. Additional information about the Hobby Airport and Shreveport Regional Airport weather stations, such as the distance between the sites and the weather stations, is provided in Table 25-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 25-3. Average Meteorological Conditions near the Texas Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Deer Park, Texas - CAMS 35									
William P. Hobby Airport 12918 (29.64, -95.28)	9.5 miles	Sample Days (30)	76.2 ± 4.2	67.7 ± 4.1	56.0 ± 5.4	61.3 ± 4.2	69.5 ± 5.1	1016.5 ± 2.0	7.4 ± 1.0
	257° (WSW)	2013	78.7 ± 1.4	69.8 ± 1.3	58.7 ± 1.5	63.4 ± 1.3	70.7 ± 1.2	1017.4 ± 0.6	6.6 ± 0.3
Karnack, Texas - CAMS 85									
Shreveport Regional Airport 13957 (32.45, -93.82)	25.2 miles	Sample Days (30)	72.5 ± 5.1	62.4 ± 5.1	51.6 ± 5.5	56.5 ± 4.8	70.5 ± 4.1	1016.0 ± 2.0	6.4 ± 1.0
	127° (SE)	2013	76.1 ± 1.7	65.6 ± 1.6	53.7 ± 1.6	58.8 ± 1.4	69.0 ± 1.3	1017.2 ± 0.6	6.0 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 25-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 25-3 is the 95 percent confidence interval for each parameter. As shown in Table 25-3, average meteorological conditions on sample days appear cooler than average weather conditions experienced throughout the year near both sites. Sampling under the NMP was discontinued at both Texas monitoring sites at the end of June 2013. Thus, the sample day averages include only samples days from the first half of the year, thereby missing some of the warmest months of the year.

25.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations at Hobby Airport near CAMS 35 and Shreveport Regional Airport near CAMS 85 were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

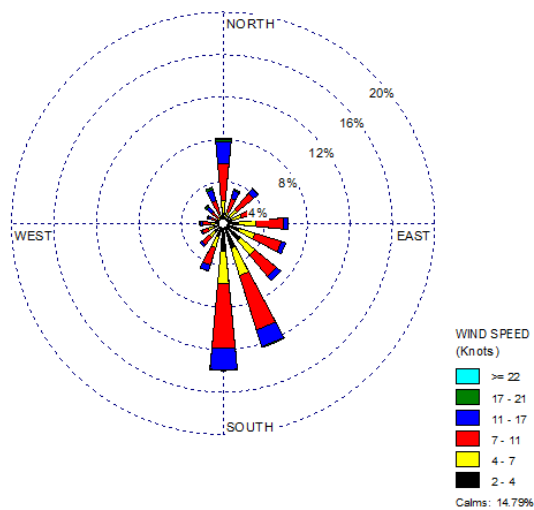
Figure 25-5 presents a map showing the distance between the weather station and CAMS 35, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 25-5 also presents three different wind roses for the CAMS 35 monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 25-6 presents the distance map and three wind roses for CAMS 85.

Figure 25-5. Wind Roses for the William P. Hobby Airport Weather Station near CAMS 35

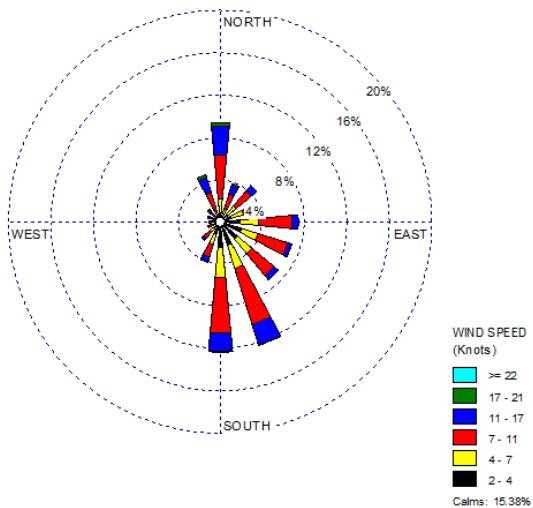
Location of CAMS 35 and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

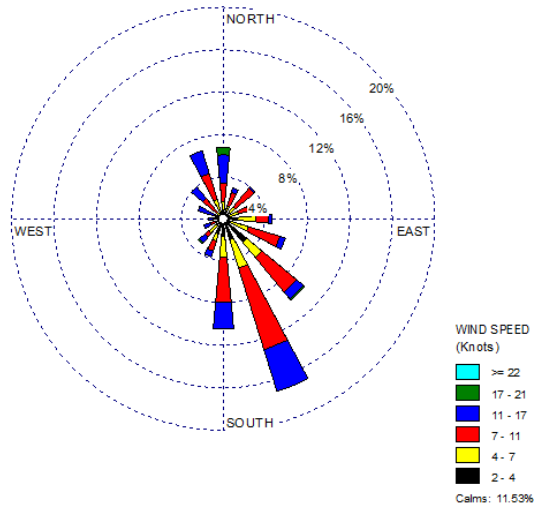
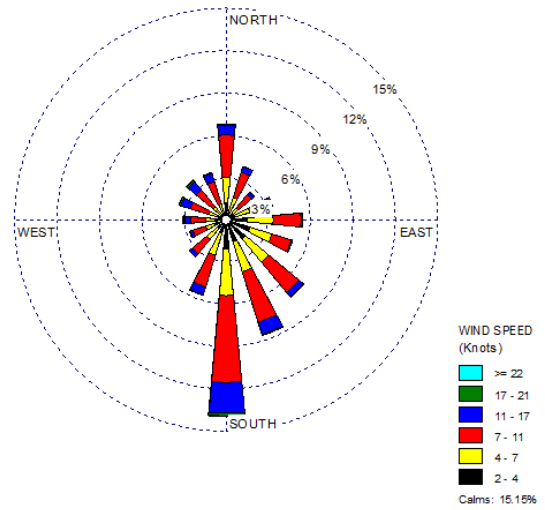


Figure 25-6. Wind Roses for the Shreveport Regional Airport Weather Station near CAMS 85

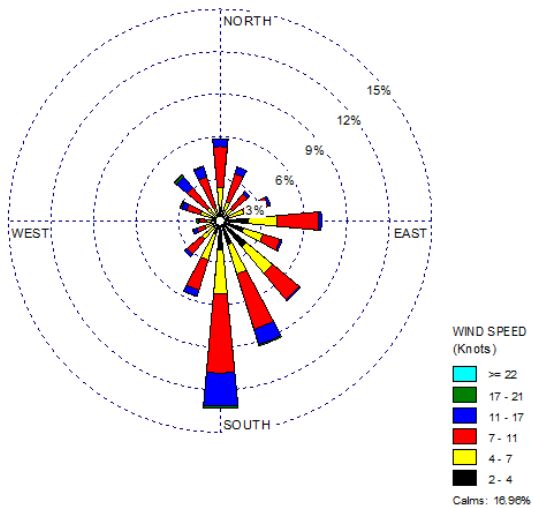
Location of CAMS 85 and Weather Station



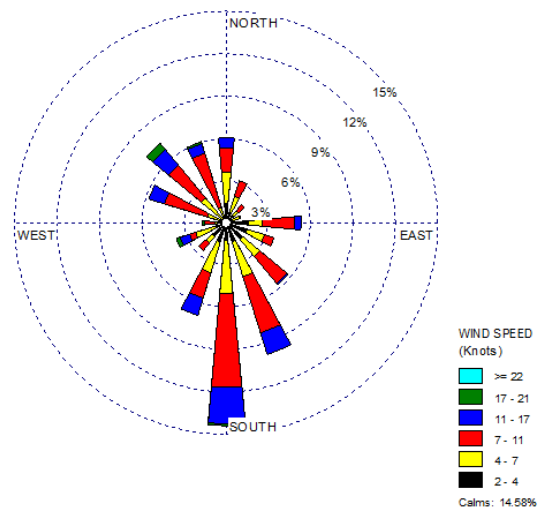
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 25-5 for CAMS 35 include the following:

- The Hobby Airport weather station is located 9.5 miles west-southwest of CAMS 35.
- The historical wind rose shows that southerly and south-southeasterly winds prevail near CAMS 35, although winds from the southeast quadrant, including easterly winds, are commonly observed. Northerly winds were also observed often. Calm winds (those less than or equal to 2 knots) were observed for approximately 15 percent of the wind measurements. Winds from the western quadrants were infrequently observed.
- The wind patterns on the wind rose for 2013 resemble the historical wind patterns; however, the percentage of northerly winds is slightly higher for 2013.
- The wind patterns shown on the sample day wind rose exhibit some differences from the wind patterns shown on the full-year and historical wind roses, with fewer southerly wind observations and a higher percentage of southeasterly and south-southeasterly wind observations. In addition, winds from the north-northwest were observed as often as winds from the north. Calm winds were also observed less frequently. Due to the shortened sampling duration, the sample day wind rose includes sample day wind data through the first half of 2013 only; a wind rose with a full year's worth of sample days may look different.

Observations from Figure 25-6 for CAMS 85 include the following:

- The Shreveport Regional Airport weather station is located across the Texas-Louisiana border, approximately 25 miles southeast of CAMS 85.
- The wind patterns on the historical wind rose for CAMS 85 resemble those on the historical wind rose for CAMS 35. The historical wind rose shows that winds from the southeast to south account for approximately 30 percent of the wind observations near the CAMS 85 site. Northerly winds were also observed often. Calm winds were observed for approximately 15 percent of the wind measurements.
- The wind patterns shown on the 2013 wind rose are similar to the historical wind patterns, indicating that wind conditions observed in 2013 are similar to those observed historically.
- Although southerly winds still prevailed, the wind patterns shown on the sample day wind rose exhibit some differences from the wind patterns shown on the full-year and historical wind roses. The primary difference is that winds from the northwest quadrant were observed more frequently, with winds from the west-northwest to north together accounting for one-quarter of the observations. Similar to CAMS 35, the sample day wind rose for CAMS 85 includes wind data through the first half of 2013 only; a wind rose with a full year's worth of sample days may look different.

25.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Texas monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 25-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 25-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Hexavalent chromium was the only pollutant sampled for at both CAMS 35 and CAMS 85, although sampling was discontinued at the end of June 2013.

Table 25-4. Risk-Based Screening Results for the Texas Monitoring Sites

Pollutant	Screening Value ($\mu\text{g}/\text{m}^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Deer Park, Texas - CAMS 35						
Hexavalent Chromium	0.000083	2	25	8.00	100.00	100.00
Total		2	25	8.00		
Karnack, Texas - CAMS 85						
Hexavalent Chromium	0.000083	0	7	0.00	0.00	0.00
Total		0	7	0.00		

Observations from Table 25-4 include the following:

- Hexavalent chromium was detected in 25 of the 30 valid samples collected at CAMS 35. This pollutant failed two screens, representing an 8 percent failure rate.
- Hexavalent chromium was detected in seven of the 30 valid samples collected at CAMS 85. This pollutant did not fail any screens for CAMS 85.
- Because CAMS 85 does not have any pollutants of interest, this site is excluded from the sections that follow, with the exception of the emissions section (Section 25.5.1).

25.4 Concentrations

This section typically presents various concentration averages used to characterize pollution levels at the monitoring site for each of the site-specific pollutants of interest. However, the short sampling duration at CAMS 35 prevents an annual average concentration for hexavalent chromium from being calculated. In order to facilitate a review of the data collected at CAMS 35 in 2013, a few statistical calculations are provided in the sections that follow. Site-specific statistical summaries for CAMS 35 (and CAMS 85) are also provided in Appendix O. The concentration comparison analysis was not performed due to the lack of an annual average concentration for CAMS 35. The trends analysis was not conducted for this site because hexavalent chromium sampling under the NMP did not begin at CAMS 35 until 2010 and was discontinued in June 2013 and therefore does not meet the criteria specified for this data analysis.

25.4.1 2013 Concentration Averages

Quarterly concentration averages were calculated for hexavalent chromium for CAMS 35, as described above. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average*, which includes all measured detections and substituted zeros for non-detects for the entire year of sampling, could not be calculated as sampling at CAMS 35 was discontinued at the end of June 2013. Quarterly average concentrations for CAMS 35 are presented in Table 25-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 25-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Texas Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
Deer Park, Texas - CAMS 35						
Hexavalent Chromium	25/30	0.06 ± 0.05	0.04 ± 0.01	NA	NA	NA

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Note: There are no pollutants of interest for CAMS 85.

Observations from Table 25-5 include the following:

- Concentrations of hexavalent chromium measured at CAMS 35 range from 0.0167 ng/m³ to 0.38 ng/m³, including five non-detects.
- The maximum hexavalent chromium concentration measured at CAMS 35 is the maximum concentration of this pollutant measured across the program, and is more than twice the next highest hexavalent chromium concentration.
- The first quarter average concentration has a relatively large confidence interval associated with it. A review of the data shows that the range of concentrations measured is wider for the first quarter. Excluding non-detects, the concentrations measured during the first quarter range from 0.0167 ng/m³ to 0.38 ng/m³ (which are the minimum and maximum measured detections), while the concentrations measured during the second quarter range from 0.0334 ng/m³ to 0.0869 ng/m³. The first quarter includes only one non-detect while four were measured during the second quarter.
- Because sampling for hexavalent chromium was discontinued in June 2013, an annual average concentration could not be calculated.

25.5 Additional Risk-Based Screening Evaluations

In order to characterize risk at participating monitoring sites, additional risk-based screening evaluations were conducted. Because an annual average concentration could not be calculated for the pollutant sampled for at CAMS 35, cancer risk and noncancer hazard approximations, as described in Section 3.4.3.3, were not calculated. The risk-based emissions assessment described in Section 3.4.3.4 was still conducted, at least in part, as the emissions can be reviewed independent of concentrations measured.

25.5.1 Risk-Based Emissions Assessment

This section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively, and is intended to help policy-makers prioritize their air monitoring activities. Table 25-6 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 25-6 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. The emissions and toxicity-weighted emissions are shown in descending order in Table 25-6. This information is provided for both counties in which each of the Texas monitoring sites are located. Table 25-7 presents similar information, but is limited to those pollutants with noncancer toxicity factors. Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. A more in-depth discussion of this analysis is provided in Section 3.4.3.4.

Observations from Table 25-6 include the following:

- Benzene, ethylbenzene, and formaldehyde are the highest emitted pollutants with cancer UREs in Harris County. Formaldehyde, benzene, and acetaldehyde are the highest emitted pollutants with cancer UREs in Harrison County. The magnitude of the emissions is substantially higher in Harris County than Harrison County.
- 1,3-Butadiene is the pollutant with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Harris County, followed by benzene and benzidine (gas). Harris County is the only county with an NMP site for which 1,3-butadiene ranks this high. The pollutants with the highest toxicity-weighted emissions for Harrison County are formaldehyde, benzene, and ethylene oxide.
- Five of the highest emitted pollutants in Harris County also have the highest toxicity-weighted emissions (1,3-butadiene, formaldehyde, benzene, ethylbenzene, and naphthalene).
- Formaldehyde and benzene top both emissions-based lists for Harrison County. Four additional pollutants appear among the highest emitted pollutants in Harrison County and also are among those with the highest toxicity-weighted emissions (naphthalene, 1,3-butadiene, ethylene oxide, and acetaldehyde).
- Hexavalent chromium, the only pollutant sampled for at the Texas monitoring sites, ranks fifth for its toxicity-weighted emissions for Harris County (CAMS 35) and seventh highest for Harrison County (CAMS 85). This pollutant is not one of the highest emitted in either county (its emissions rank 29th and 30th, for each respective county).

Table 25-6. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Texas Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Deer Park, Texas (Harris County) - CAMS 35					
Benzene	1,159.59	1,3-Butadiene	1.02E-02		
Ethylbenzene	736.97	Benzene	9.04E-03		
Formaldehyde	665.99	Benzidine, gas	8.83E-03		
Acetaldehyde	415.50	Formaldehyde	8.66E-03		
1,3-Butadiene	341.18	Hexavalent Chromium	7.25E-03		
Methyl <i>tert</i> butyl ether	109.34	Naphthalene	3.51E-03		
Naphthalene	103.35	Nickel, PM	2.28E-03		
Propylene oxide	59.07	Ethylene oxide	2.23E-03		
Dichloromethane	49.16	Ethylbenzene	1.84E-03		
Trichloroethylene	27.72	Acrylonitrile	1.79E-03		
Karnack, Texas (Harrison County) - CAMS 85					
Formaldehyde	127.17	Formaldehyde	1.65E-03		
Benzene	82.70	Benzene	6.45E-04		
Acetaldehyde	55.09	Ethylene oxide	5.91E-04		
Ethylbenzene	35.08	Naphthalene	5.14E-04		
Naphthalene	15.11	Nickel, PM	3.50E-04		
1,3-Butadiene	11.35	1,3-Butadiene	3.40E-04		
Ethylene oxide	6.72	Hexavalent Chromium	1.88E-04		
Dichloromethane	2.61	Arsenic, PM	1.39E-04		
Tetrachloroethylene	1.71	Acetaldehyde	1.21E-04		
Benzyl chloride	1.37	POM, Group 2b	9.98E-05		

Table 25-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Texas Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Deer Park, Texas (Harris County) - CAMS 35					
Toluene	4,895.12	Acrolein	2,446,074.13		
Hexane	4,300.06	1,3-Butadiene	170,588.08		
Methanol	2,807.01	Chlorine	120,849.93		
Xylenes	2,750.29	Titanium tetrachloride	77,090.00		
Benzene	1,159.59	Formaldehyde	67,958.53		
Ethylene glycol	824.11	Nickel, PM	52,732.60		
Ethylbenzene	736.97	Acetaldehyde	46,166.51		
Formaldehyde	665.99	Benzene	38,653.10		
Methyl isobutyl ketone	609.10	Cadmium, PM	37,230.00		
Acetaldehyde	415.50	Naphthalene	34,450.67		
Karnack, Texas (Harrison County) - CAMS 85					
Toluene	189.46	Acrolein	647,248.74		
Xylenes	172.55	Hexamethylene-1,6-diisocyanate, gas	48,091.54		
Formaldehyde	127.17	Chlorine	22,538.67		
Hexane	111.73	Formaldehyde	12,977.02		
Ethylene glycol	91.50	Cyanide Compounds, PM	9,151.68		
Benzene	82.70	Nickel, PM	8,094.58		
Acetaldehyde	55.09	Maleic anhydride	7,969.71		
Methanol	50.13	Acetaldehyde	6,120.78		
Chloromethane	48.40	1,3-Butadiene	5,674.42		
Ethylbenzene	35.08	Naphthalene	5,037.99		

Observations from Table 25-7 include the following:

- Toluene is the highest emitted pollutant with a noncancer RfC in both Harris and Harrison Counties. The magnitude of the emissions is substantially higher for Harris County than Harrison County.
- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties is acrolein.
- Three of the highest emitted pollutants also have the highest toxicity-weighted emissions for Harris County (formaldehyde, acetaldehyde, and benzene) while only two of the highest emitted pollutants (formaldehyde and acetaldehyde) also have the highest toxicity-weighted emissions for Harrison County.
- Hexavalent chromium appears on neither emissions-based list for Harris County, ranking 62nd for its total emissions and 23rd for its toxicity-weighted emissions (of the pollutants with noncancer RfCs).
- Hexavalent chromium appears on neither emissions-based list for Harrison County, ranking 60th for its total emissions and 30th for its toxicity-weighted emissions (of the pollutants with noncancer RfCs).

25.6 Summary of the 2013 Monitoring Data for CAMS 35 and CAMS 85

Results from several of the data treatments described in this section include the following:

- ❖ *Hexavalent chromium was the only pollutant sampled for at CAMS 35 and CAMS 85 in 2013. Sampling was discontinued at these locations at the end of June.*
- ❖ *Hexavalent chromium was detected in more than 80 percent of samples collected at CAMS 35 and failed two screens.*
- ❖ *Hexavalent chromium was detected in fewer than 25 percent of samples collected at CAMS 85. Concentrations of hexavalent chromium did not fail any screens for CAMS 85.*
- ❖ *The highest concentration of hexavalent chromium across the program was measured at CAMS 35.*

26.0 Site in Utah

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Utah, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

26.1 Site Characterization

This section characterizes the Utah monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The BTUT monitoring site is located in Bountiful, in northern Utah. Figure 26-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 26-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 26-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 26-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 26-1. Bountiful, Utah (BTUT) Monitoring Site

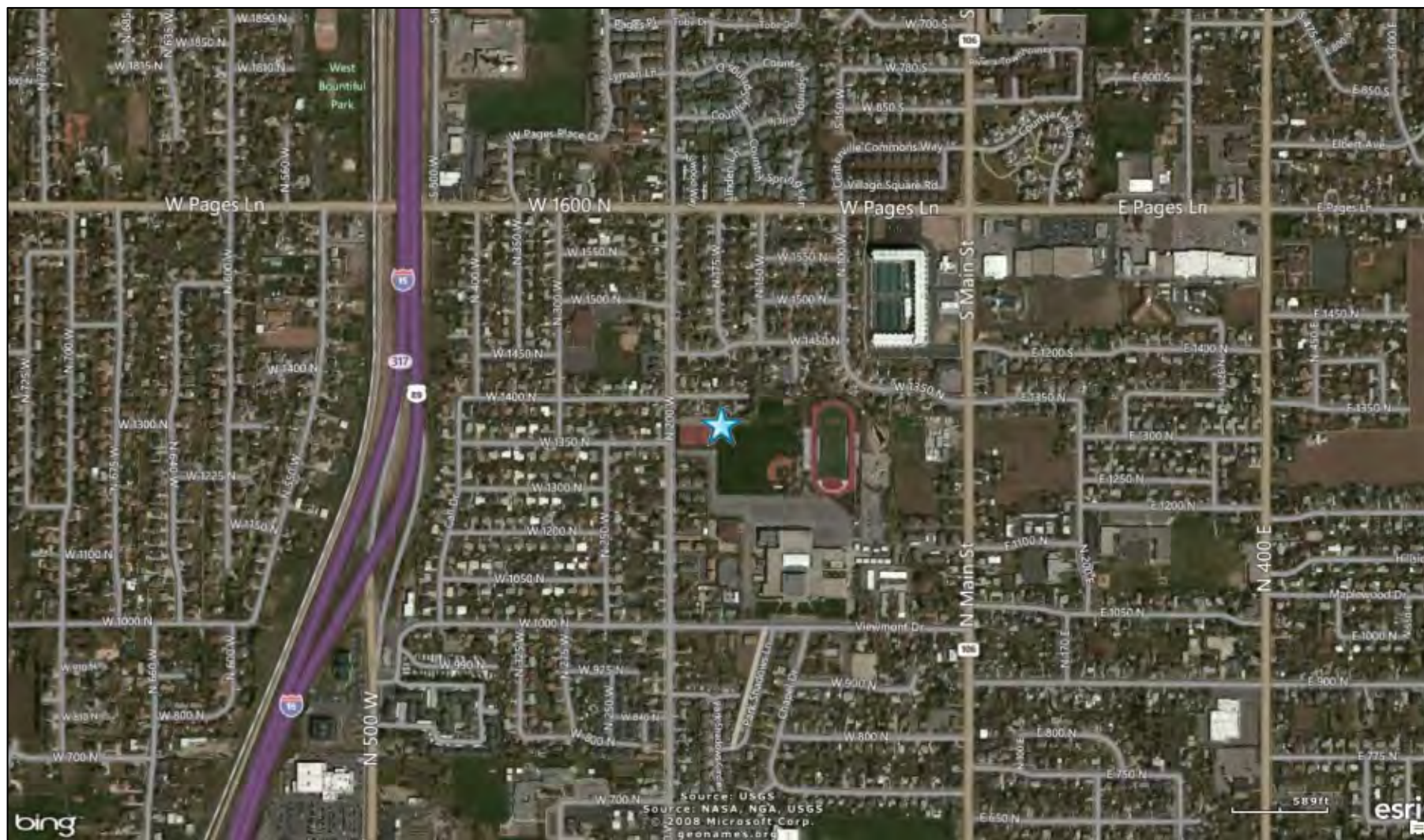


Figure 26-2. NEI Point Sources Located Within 10 Miles of BTUT

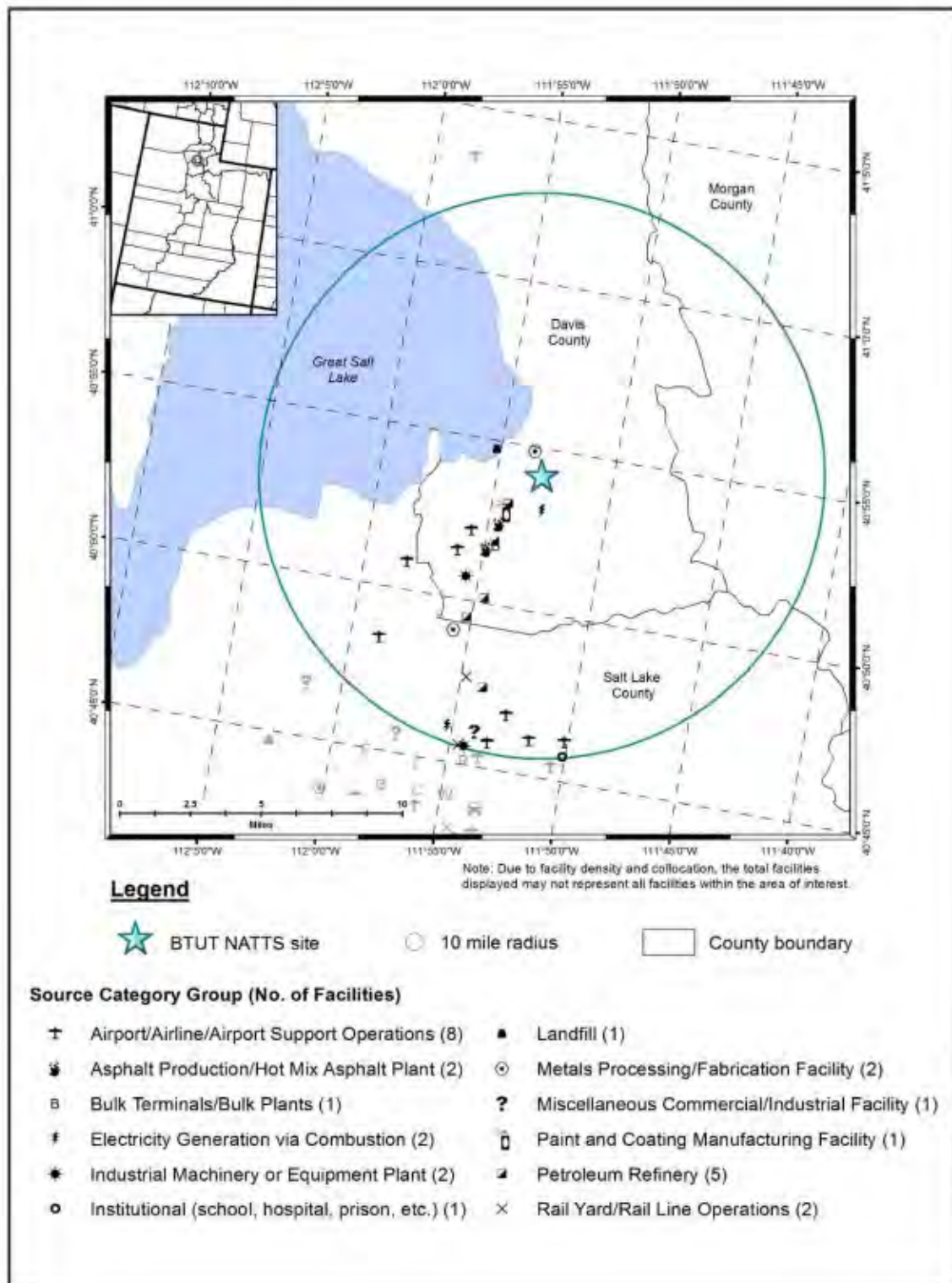


Table 26-1. Geographical Information for the Utah Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>BTUT</i>	49-011-0004	Bountiful	Davis	Ogden-Clearfield, UT	40.902967, -111.884467	Residential	Suburban	SO ₂ , NO, NO ₂ , NO _x , O ₃ , Meteorological parameters, PM ₁₀ , PM _{2.5} , PM _{2.5} Speciation, Black Carbon, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for BTUT (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

Bountiful is north of Salt Lake City and is situated in a valley between the Great Salt Lake to the west and the Wasatch Mountains to the east. Figure 26-1 shows that BTUT is located on the property of Viewmont High School, in a primarily residential area. The site is located about one-third of a mile from I-15, which runs north-south through most of the surrounding urban area including Salt Lake City, Clearfield, and Ogden. Figure 26-2 shows that most of the point sources near BTUT are located to the south of the site and run parallel to I-15. The facilities surrounding BTUT are involved in a variety of industries, although the source categories with the greatest number of point sources surrounding BTUT are the airport and airport support operations category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations, and petroleum refineries. Point sources within 2 miles of BTUT include a metals processing/fabrication facility, a facility generating electricity via combustion, a petroleum refinery, a painting and coatings manufacturer, and a landfill.

Table 26-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Utah monitoring site. Table 26-2 includes both county-level population and vehicle registration information. Table 26-2 also contains traffic volume information for BTUT as well as the location for which the traffic volume was obtained. Additionally, Table 26-2 presents the county-level daily VMT for Davis County.

Table 26-2. Population, Motor Vehicle, and Traffic Information for the Utah Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
<i>BTUT</i>	Davis	322,094	274,716	130,950	I-15, N of Hwy 89 junction	6,950,795

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2013 data (UT TC, 2013)

³AADT reflects 2012 data (UT DOT, 2012)

⁴County-level VMT reflects 2013 data (UT DOT, 2014)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 26-2 include the following:

- Davis County's population is in the middle of the range compared to other counties with NMP sites. The county-level vehicle registration ranking is similar to the population ranking.

- The traffic volume experienced near BTUT is in the top third compared to the traffic volumes for other NMP sites. The traffic estimate provided is for I-15, north of the Highway 89 junction, just west of the site.
- The daily VMT for Davis County is in the middle of the range compared to other counties with NMP sites.

26.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Utah on sample days, as well as over the course of the year.

26.2.1 Climate Summary

The Salt Lake City area's climate can be described as semi-arid and continental with considerable seasonal variations. Summers are hot and dry while winters are cold and snow is common. The area is generally dry, though, and sunshine prevails across the area during much of the year. Most months average less than 2 inches of precipitation, with spring as the wettest season. Precipitation that does fall can be enhanced over the eastern parts of the valley as storm systems move up the side of the Wasatch Mountains, located to the east. Smaller mountain ranges to the southwest and south protect the valley from winter storm systems moving in from the southwest. The Great Salt Lake has a moderating influence on the area's temperature, as the lake never freezes, and can enhance precipitation from storm systems that move over the lake. Moderate winds flow out of the southeast on average, although there is a valley breeze/lake breeze system that affects the area. High pressure systems that occasionally settle over the area can result in stagnation episodes (Wood 2004; WRCC, 2014).

26.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Utah monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station to BTUT is located at Salt Lake City International Airport (WBAN 24127). Additional information about the Salt Lake City International Airport weather station, such as the distance between the site and the weather station, is provided in Table 26-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 26-3. Average Meteorological Conditions near the Utah Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Bountiful, Utah - BTUT									
Salt Lake City International 24127 (40.78, -111.97)	9.7 miles 207° (SSW)	Sample Days (78)	64.1 ± 5.6	54.3 ± 5.1	31.6 ± 3.0	43.0 ± 3.5	48.8 ± 4.3	1016.5 ± 2.1	6.0 ± 0.6
		2013	63.0 ± 2.5	53.3 ± 2.3	31.3 ± 1.3	42.5 ± 1.6	50.2 ± 2.1	1016.4 ± 0.9	6.1 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 26-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 26-3 is the 95 percent confidence interval for each parameter. As shown in Table 26-3, average meteorological conditions on sample days near BTUT were representative of average weather conditions experienced throughout the year. Note that the number of sample days (78) is larger than a 1-in-6 day sampling schedule would typically present; a number of make-up samples were collected at BTUT, primarily between April and September as well as December.

As indicated in the previous section, BTUT is located in a relatively dry climate. The average relative humidity shown in Table 26-3 is the second lowest, second only to the relative humidity calculated for the Phoenix, Arizona sites. The average dew point temperature calculated for BTUT is also among the lowest compared to other NMP sites.

26.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at Salt Lake City International Airport near BTUT were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

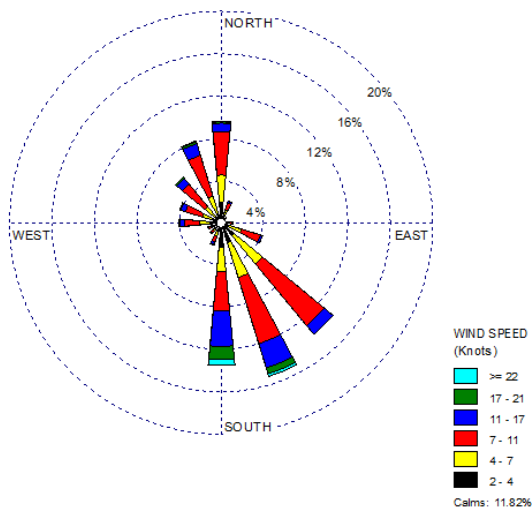
Figure 26-3 presents a map showing the distance between the weather station and BTUT, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 26-3 also presents three different wind roses for the BTUT monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 26-3. Wind Roses for the Salt Lake City International Airport Weather Station near BTUT

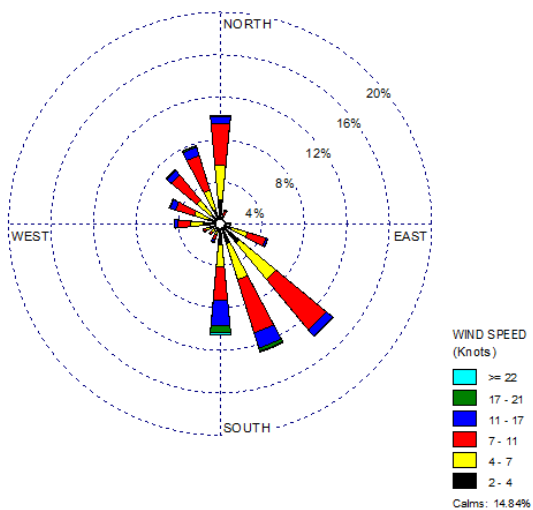
Location of BTUT and Weather Station



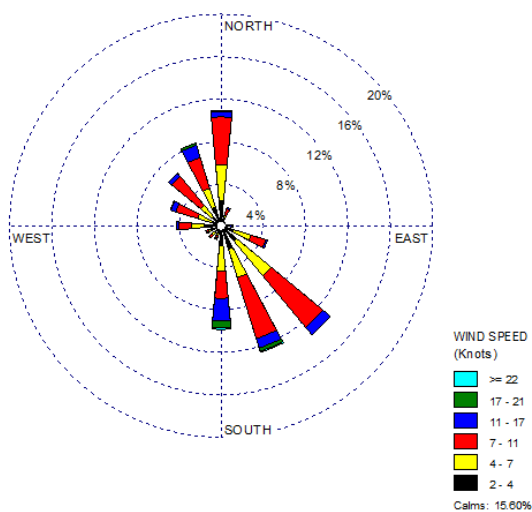
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 26-3 for BTUT include the following:

- The Salt Lake City International Airport weather station is located 9.7 miles south-southwest of BTUT.
- The historical wind rose shows that southeasterly, south-southeasterly, and southerly winds were prevalent near BTUT, accounting for more than 40 percent of the wind observations. Winds from the north-northwest and north were also commonly observed. Winds from the northeast and southwest quadrants were rarely observed. Calm winds (those less than or equal to 2 knots) were observed for approximately 12 percent of the hourly measurements. The strongest wind speeds were observed with south-southeasterly and southerly winds.
- The wind patterns shown on the 2013 wind rose are similar to the historical wind patterns, indicating that wind conditions in 2013 were similar to wind conditions experienced historically near BTUT. There are, however, a few differences between the historical and the 2013 wind roses. The 2013 wind rose has a higher percentage of calm winds than the historical wind rose, with nearly 15 percent of the observations identified as calm. Also, the number of south-southeasterly and southerly winds observed is less than on the historical wind rose.
- The wind patterns shown on the sample day wind rose are very similar to the full-year wind patterns.

26.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the Utah monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 26-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 26-4. It is important to note which pollutants each site sampled for when reviewing the results of this analysis. VOCs, carbonyl compounds, SNMOCs, PAHs, metals (PM₁₀), and hexavalent chromium were sampled for at BTUT, although sampling for hexavalent chromium was discontinued in June 2013. BTUT is one of only two NMP sites sampling the entire suite of pollutants under the NMP (NBIL is the other).

Table 26-4. Risk-Based Screening Results for the Utah Monitoring Site

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Bountiful, Utah - BTUT						
Acetaldehyde	0.45	55	55	100.00	11.29	11.29
Formaldehyde	0.077	55	55	100.00	11.29	22.59
Benzene	0.13	53	53	100.00	10.88	33.47
Carbon Tetrachloride	0.17	52	53	98.11	10.68	44.15
Arsenic (PM ₁₀)	0.00023	49	59	83.05	10.06	54.21
1,3-Butadiene	0.03	47	50	94.00	9.65	63.86
Naphthalene	0.029	42	56	75.00	8.62	72.48
1,2-Dichloroethane	0.038	38	38	100.00	7.80	80.29
Propionaldehyde	0.8	35	55	63.64	7.19	87.47
Ethylbenzene	0.4	13	53	24.53	2.67	90.14
Dichloromethane	60	12	53	22.64	2.46	92.61
Nickel (PM ₁₀)	0.0021	10	59	16.95	2.05	94.66
<i>p</i> -Dichlorobenzene	0.091	8	19	42.11	1.64	96.30
Cadmium (PM ₁₀)	0.00056	3	59	5.08	0.62	96.92
Hexachloro-1,3-butadiene	0.045	3	3	100.00	0.62	97.54
Lead (PM ₁₀)	0.015	3	59	5.08	0.62	98.15
Xylenes	10	3	53	5.66	0.62	98.77
Acenaphthylene	0.011	2	34	5.88	0.41	99.18
Benzo(a)pyrene	0.00057	2	22	9.09	0.41	99.59
Chloroprene	0.0021	1	1	100.00	0.21	99.79
1,2-Dibromoethane	0.0017	1	1	100.00	0.21	100.00
Total		487	890	54.72		

Observations from Table 26-4 include the following:

- Twenty-one pollutants failed at least one screen for BTUT; nearly 55 percent of concentrations for these 21 pollutants were greater than their associated risk screening value (or failed screens). BTUT tied with S4MO for the highest number of individual pollutants failing screens.
- Thirteen pollutants contributed to 95 percent of failed screens for BTUT and therefore were identified as pollutants of interest for this site. These 13 include three carbonyl compounds, seven VOCs, two PM₁₀ metals, and one PAH.
- Acetaldehyde, formaldehyde, and benzene were detected in every valid carbonyl compound and VOC sample collected at BTUT and failed 100 percent of screens. Other pollutants also failed 100 percent of screens but were detected less frequently.

- Recall from Section 3.2 that if a pollutant was measured by both the TO-15 and SNMOC methods at the same site, the TO-15 results were used for the risk-based screening process. As BTUT sampled both VOCs (TO-15) and SNMOCs, the TO-15 results were used for the 12 pollutants these methods have in common.

26.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Utah monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at BTUT are provided in Appendix J through Appendix O.

26.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for BTUT, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Utah monitoring site are presented in Table 26-5, where applicable. Fourth quarter average concentrations could not be calculated for the VOCs because fewer than 75 percent of the samples collected were valid. First

quarter average concentrations could not be calculated for the PAHs because the sampler was not operating properly and was not repaired in time for make-up samples to be collected. Note that concentrations of the PAHs and PM₁₀ metals are presented in ng/m³ in Table 26-5 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average concentration simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 26-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Utah Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
Bountiful, Utah - BTUT						
Acetaldehyde	55/55	5.44 ± 0.85	3.99 ± 0.48	4.26 ± 0.56	3.11 ± 0.58	4.18 ± 0.36
Benzene	53/53	1.19 ± 0.32	0.58 ± 0.13	0.68 ± 0.17	NA	0.94 ± 0.16
1,3-Butadiene	50/53	0.11 ± 0.04	0.04 ± 0.01	0.04 ± 0.02	NA	0.09 ± 0.02
Carbon Tetrachloride	53/53	0.57 ± 0.06	0.58 ± 0.04	0.58 ± 0.02	NA	0.56 ± 0.03
<i>p</i> -Dichlorobenzene	19/53	0.02 ± 0.02	0.06 ± 0.08	0.04 ± 0.04	NA	0.05 ± 0.03
1,2-Dichloroethane	38/53	0.06 ± 0.03	0.10 ± 0.03	0.02 ± 0.02	NA	0.11 ± 0.03
Dichloromethane	53/53	17.77 ± 26.41	332.69 ± 674.34	451.06 ± 274.86	NA	225.03 ± 219.72
Ethylbenzene	53/53	0.32 ± 0.10	0.24 ± 0.08	0.28 ± 0.06	NA	0.49 ± 0.24
Formaldehyde	55/55	10.27 ± 1.72	9.15 ± 1.03	8.71 ± 1.15	3.78 ± 0.86	8.05 ± 0.87
Propionaldehyde	55/55	1.09 ± 0.13	0.93 ± 0.10	1.00 ± 0.11	0.53 ± 0.11	0.89 ± 0.08
Arsenic (PM ₁₀) ^a	59/59	0.96 ± 0.58	0.41 ± 0.11	0.45 ± 0.13	2.23 ± 1.46	0.99 ± 0.40
Naphthalene ^a	56/56	NA	28.11 ± 7.18	40.70 ± 5.85	79.93 ± 20.41	55.48 ± 11.39
Nickel (PM ₁₀) ^a	59/59	1.40 ± 0.49	0.89 ± 0.21	1.37 ± 0.26	2.17 ± 0.69	1.44 ± 0.24

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

^a Average concentrations provided for the pollutant below the blue line are presented in ng/m³ for ease of viewing.

Observations for BTUT from Table 26-5 include the following:

- The pollutants with the highest annual average concentrations are dichloromethane, formaldehyde, acetaldehyde, and benzene, consistent with the last several years of sampling.
- Dichloromethane has the highest annual average concentration for BTUT again for 2013, but is considerably higher than the annual averages calculated for 2012 and 2011. The annual average concentration for 2013 has a very large confidence interval associated it, indicating the likely presence of outliers, as do the quarterly average concentrations. A review of the data shows that concentrations of dichloromethane measured at BTUT in 2013 range from 0.585 $\mu\text{g}/\text{m}^3$ to 5,604 $\mu\text{g}/\text{m}^3$. The maximum concentration of this pollutant was measured on June 3, 2013 and is one of three dichloromethane concentrations greater than 1,000 $\mu\text{g}/\text{m}^3$ measured at this site. Eleven of the 12 dichloromethane concentrations greater than 100 $\mu\text{g}/\text{m}^3$ measured across the program were measured at BTUT. The median concentration of dichloromethane for BTUT is 5.85 $\mu\text{g}/\text{m}^3$, which is greater than all but one of the other NMP sites annual average dichloromethane concentrations, indicating that the statistics for this site are not being thrown off just by one or two outliers. Four of the five highest dichloromethane concentrations measured at BTUT were measured between August 1, 2013 and September 1, 2013 and 10 of the 12 concentrations greater than 50 $\mu\text{g}/\text{m}^3$ were measured between June and September (with the other two in January and December). All of the concentrations less than 2 $\mu\text{g}/\text{m}^3$ were measured during the first half of 2013 and predominantly during the second quarter of the year (with two measured during the first quarter, nine measured during the second, and one measured during the third).
- Based on the quarterly average concentrations of formaldehyde, concentrations measured during the fourth quarter of the year are significantly lower than those measured during the rest of the year. A review of the data shows that formaldehyde concentrations measured at BTUT range from 2.13 $\mu\text{g}/\text{m}^3$ to 14.9 $\mu\text{g}/\text{m}^3$. All but one of the 13 concentrations less than 5 $\mu\text{g}/\text{m}^3$ were measured between October and December, with the maximum concentration measured during this period less than the median formaldehyde concentration calculated for the year. Conversely, the five highest concentrations were measured at BTUT between the end of January and the end of February and were greater than or equal to 12 $\mu\text{g}/\text{m}^3$. Similar observations can be made for propionaldehyde and, to a lesser extent, acetaldehyde.
- Based on the three quarterly average concentrations of benzene available for BTUT, concentrations are significantly higher during the first quarter. A review of the data shows that the maximum concentration of benzene (3.65 $\mu\text{g}/\text{m}^3$) was actually measured in December. Concentrations measured in December account for five of the nine highest benzene concentrations measured at this site, with the other four measured in either January or February. Of the 18 benzene concentrations greater than 1 $\mu\text{g}/\text{m}^3$ measured at BTUT, most were measured during the colder months of the year (six during the first quarter, one during the second quarter, two during the third quarter, and nine during the fourth quarter). Similar observations can be made for 1,3-butadiene and, to a lesser extent, ethylbenzene. Note that for ethylbenzene, the annual average concentration shown in Table 26-5 is greater than the three available

quarterly average concentrations. The three ethylbenzene concentrations measured between December 13, 2013 and December 18, 2013 are the only ethylbenzene concentrations greater than $1 \mu\text{g}/\text{m}^3$ measured at BTUT and range from $2.85 \mu\text{g}/\text{m}^3$ to $5.53 \mu\text{g}/\text{m}^3$, all three of which are among the higher ethylbenzene concentrations measured across the program.

- Similar to ethylbenzene, the annual average concentration of 1,2-dichloroethane shown in Table 26-5 is greater than the three available quarterly average concentrations. Five of the six highest 1,2-dichloroethane concentrations measured at BTUT were measured in December, with concentrations measured during the fourth quarter comprising 11 of the 13 highest 1,2-dichloroethane concentrations measured at this site.
- The available quarterly average concentrations of *p*-dichlorobenzene each have relatively large confidence intervals, particularly the second quarter, for which the confidence interval is larger than the average itself. A review of the data shows that this pollutant was detected in 36 percent of the samples collected, such that many zeroes substituted for non-detects are included in each quarterly average (the number of measured detections ranges from three to four for the first three calendar quarters and eight for fourth quarter). The two highest concentrations of *p*-dichlorobenzene were measured at BTUT during the second quarter, on May 16, 2013 ($0.681 \mu\text{g}/\text{m}^3$) and April 28, 2013 ($0.205 \mu\text{g}/\text{m}^3$), the first of which is the maximum *p*-dichlorobenzene concentration measured across the program.
- The fourth quarter average arsenic concentration is considerably higher than the other quarterly averages and has a relatively large confidence interval associated with it (although this is also true for the first quarter average). A review of the data shows that the three highest arsenic concentrations measured at BTUT were measured in November and December and range from $5.22 \text{ ng}/\text{m}^3$ to $9.18 \text{ ng}/\text{m}^3$, accounting for three of the five highest arsenic concentrations measured across the program, including the maximum. All 11 arsenic concentrations greater than or equal to $1 \text{ ng}/\text{m}^3$ were measured at BTUT during the first (five) or fourth (six) quarters of the year.
- Concentrations of nickel measured at BTUT range from $0.31 \text{ ng}/\text{m}^3$ to $5.08 \text{ ng}/\text{m}^3$, with seven of the nine highest concentrations of nickel measured at BTUT between October and December (with the other two measured in January and February). Of the 20 highest nickel concentrations measured at BTUT, six were measured during the first quarter, none were measured during the second quarter, four were measured during the third quarter, and 10 were measured during the fourth quarter.
- Concentrations of naphthalene appear highest during the fourth quarter of the year, based on the available quarterly average concentrations. Concentrations of naphthalene measured at BTUT range from $8.29 \text{ ng}/\text{m}^3$ to $242 \text{ ng}/\text{m}^3$, with the maximum concentration of naphthalene measured on January 4, 2013. The seven concentrations of naphthalene greater than $100 \text{ ng}/\text{m}^3$ were all measured in January, November, or December. Of the 15 concentrations greater than $65 \text{ ng}/\text{m}^3$ measured at

BTUT, five were measured during the first quarter and 10 were measured during the fourth quarter.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for BTUT from those tables include the following:

- BTUT appears in Table 4-9 through 4-12 a total of seven times for the program-level pollutants of interest.
- BTUT is listed for three of the program-level VOC pollutants of interest shown in Table 4-9. BTUT ranks highest for ethylbenzene, ranking fifth among other NMP sites sampling this pollutant. BTUT also ranks sixth for 1,2-dichloroethane and 10th for *p*-dichlorobenzene.
- For the third year in a row, BTUT has the highest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds, as shown in Table 4-10. BTUT also ranks highest for its annual average concentration of acetaldehyde.
- BTUT does not appear in Table 4-11 for PAHs. This site's annual average concentrations of the PAHs are among the lower averages for sites sampling PAHs.
- BTUT ranks second highest for its annual average concentration of arsenic, as shown in Table 4-12. The annual average arsenic concentration calculated for BTUT has the highest confidence interval shown in Table 4-12 for arsenic. BTUT's annual average concentration ranks fourth highest for nickel.

26.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 26-4 for BTUT. Figures 26-4 through 26-16 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 26-4. Program vs. Site-Specific Average Acetaldehyde Concentration

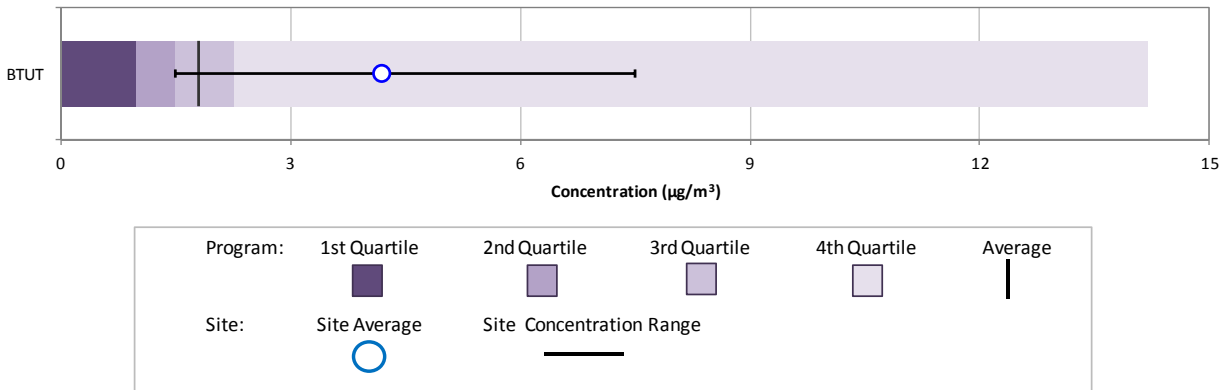


Figure 26-5. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

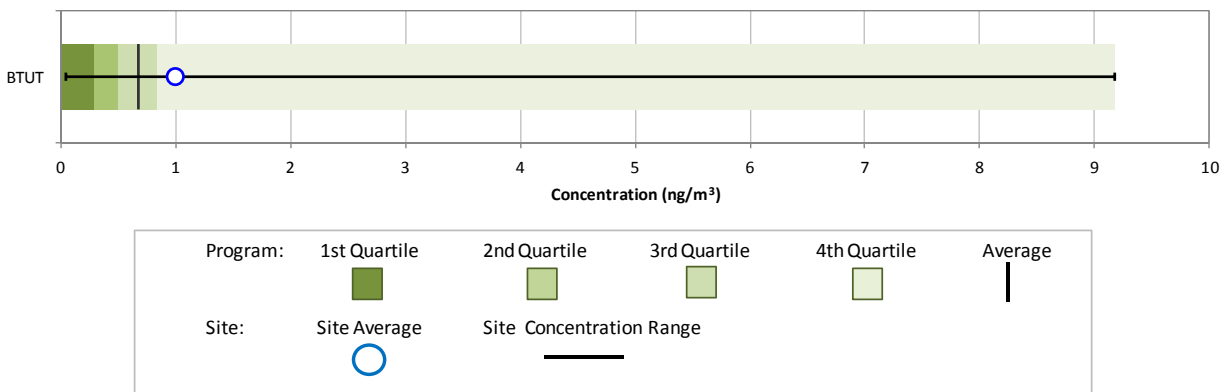


Figure 26-6. Program vs. Site-Specific Average Benzene Concentration

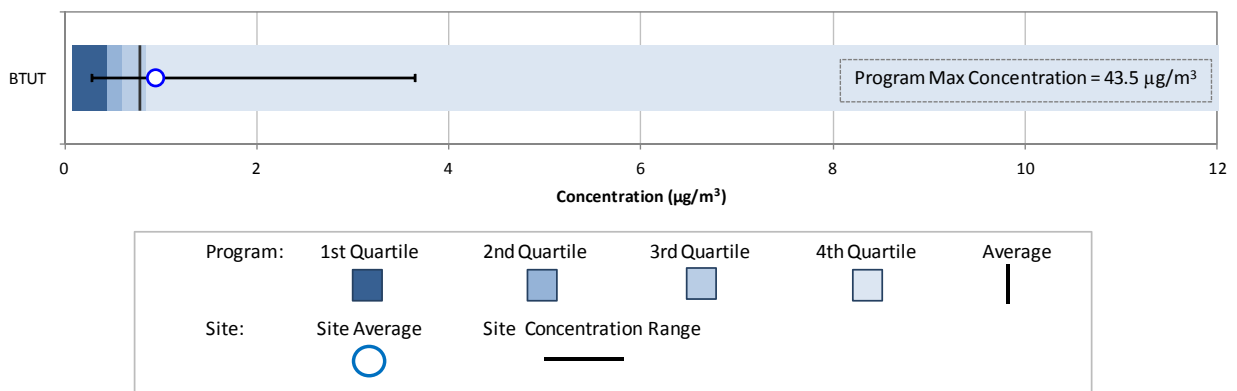


Figure 26-7. Program vs. Site-Specific Average 1,3-Butadiene Concentration

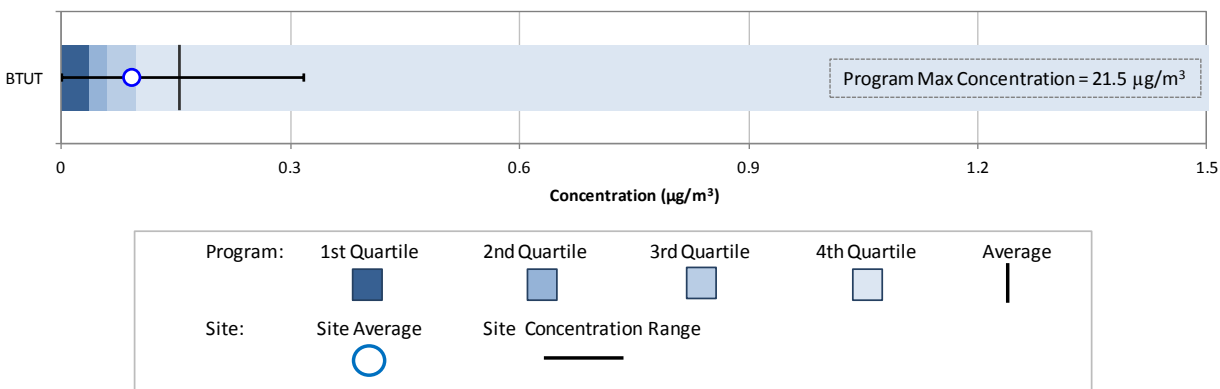


Figure 26-8. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

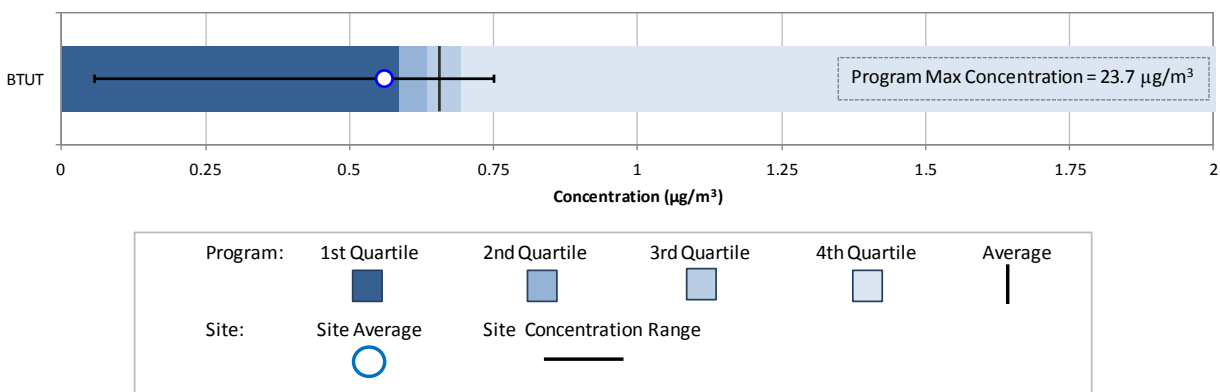


Figure 26-9. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentration

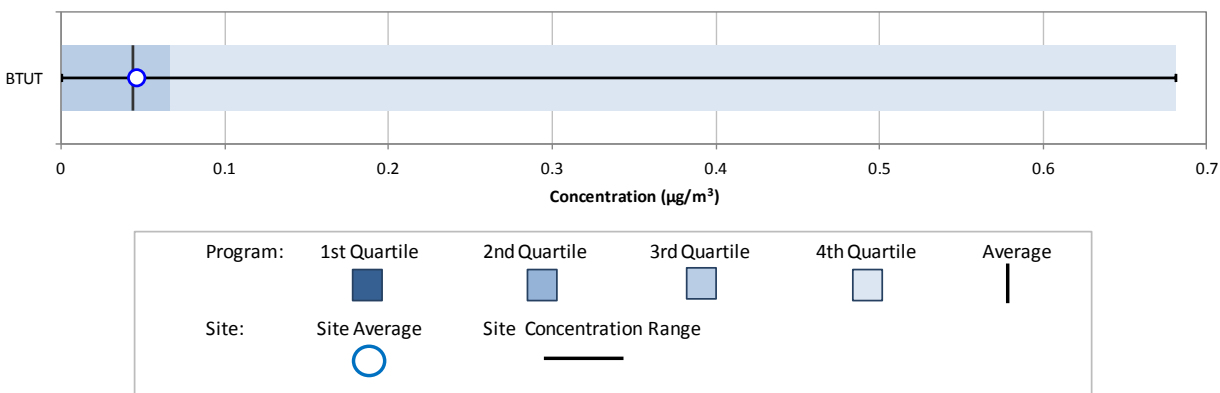


Figure 26-10. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

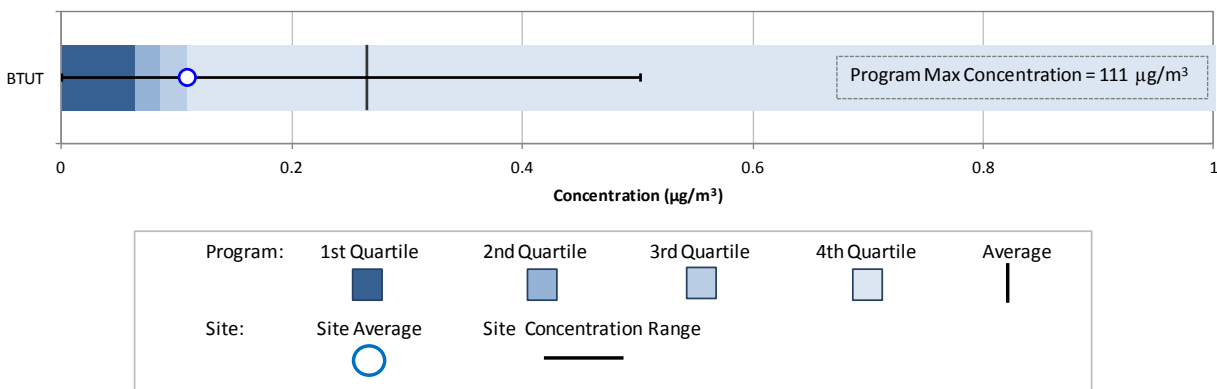


Figure 26-11. Program vs. Site-Specific Average Dichloromethane Concentration

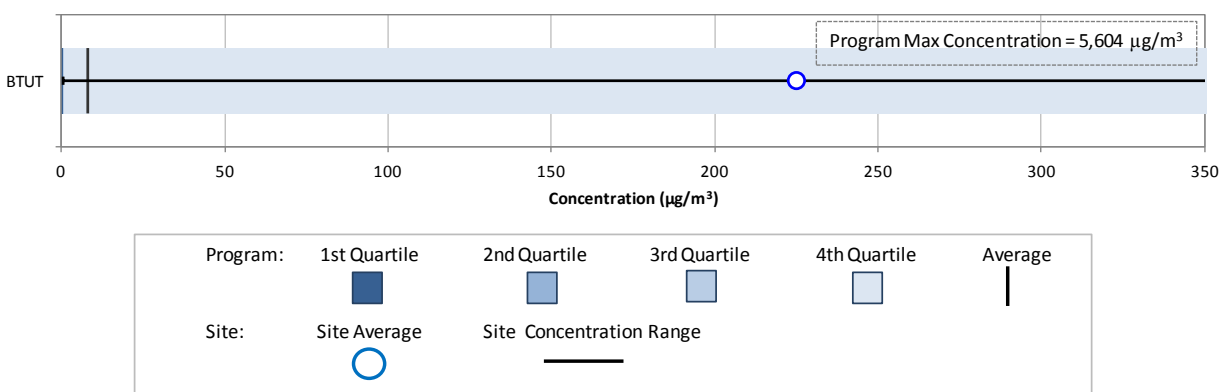


Figure 26-12. Program vs. Site-Specific Average Ethylbenzene Concentration

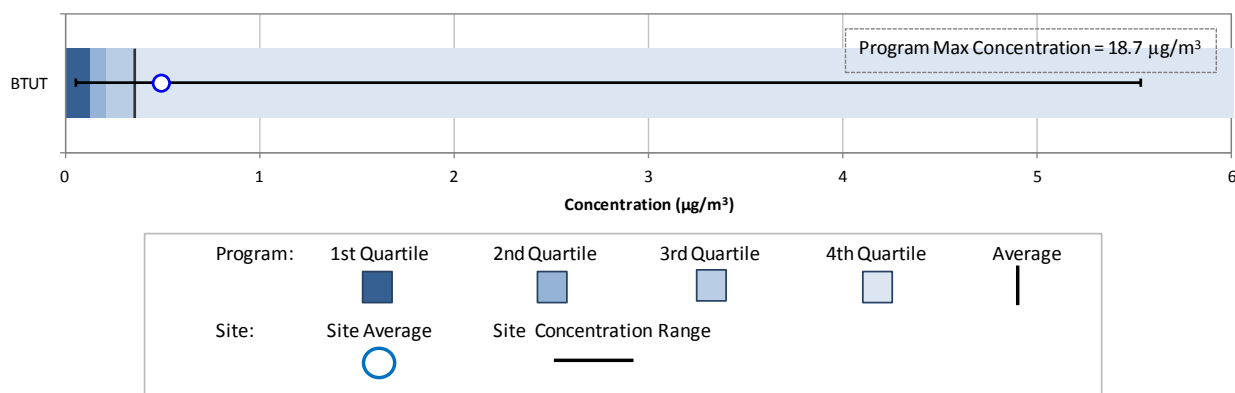


Figure 26-13. Program vs. Site-Specific Average Formaldehyde Concentration

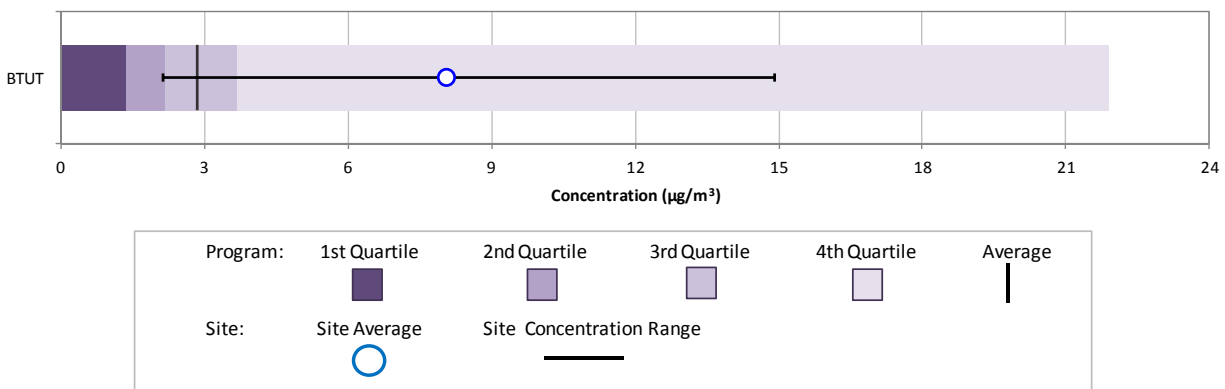


Figure 26-14. Program vs. Site-Specific Average Naphthalene Concentration

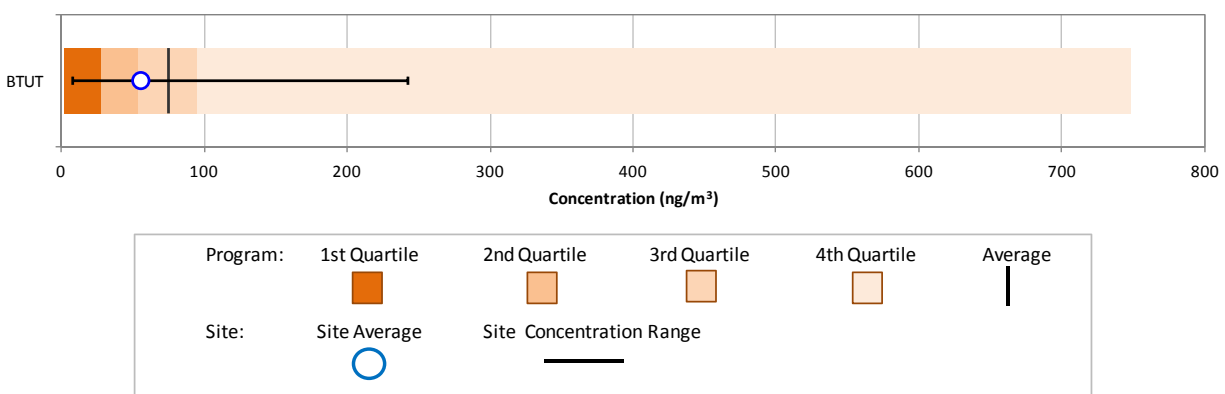


Figure 26-15. Program vs. Site-Specific Average Nickel (PM_{10}) Concentration

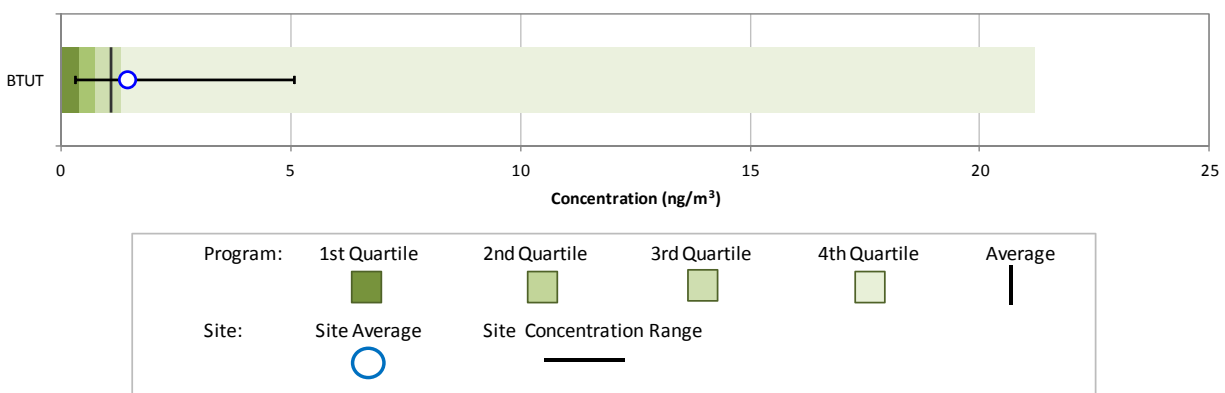
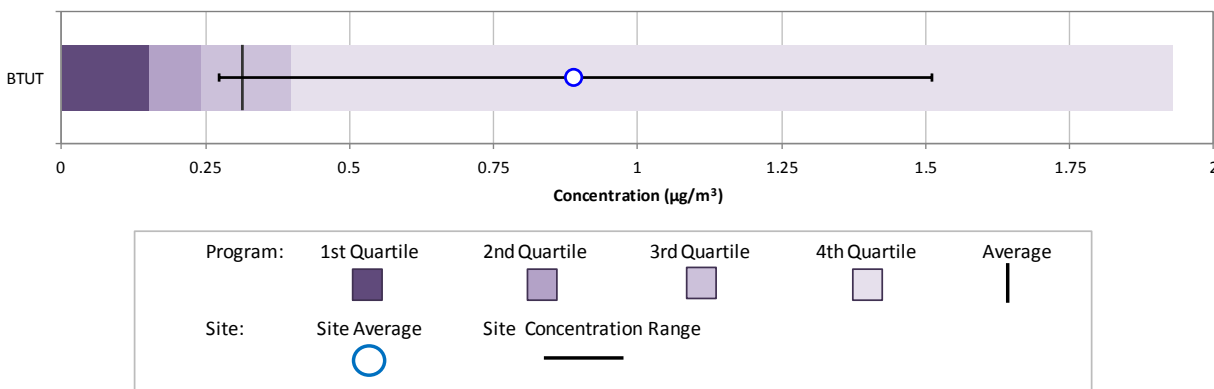


Figure 26-16. Program vs. Site-Specific Average Propionaldehyde Concentration



Observations from Figures 26-4 through 26-16 include the following:

- Figure 26-4 shows that the maximum acetaldehyde concentration measured at BTUT is roughly half the maximum acetaldehyde concentration measured at the program-level. The box plot also shows that the minimum acetaldehyde concentration measured at BTUT ($1.49 \mu\text{g}/\text{m}^3$) is equal to the program-level median concentration. BTUT is one of only two NMP sites whose minimum concentration is greater than $1 \mu\text{g}/\text{m}^3$. The annual average acetaldehyde concentration for BTUT is more than twice the program-level average concentration, is greater than the program-level third quartile, and is the highest annual average concentration among NMP sites sampling carbonyl compounds.
- Figure 26-5 for arsenic shows that BTUT's maximum arsenic concentration is the maximum arsenic concentration measured at the program-level. The annual average concentration calculated for BTUT is greater than the program-level average concentration and third quartile and is the second highest among NMP sites sampling PM_{10} metals.
- Figure 26-6 presents the box plot for benzene. Note that the program-level maximum benzene concentration ($43.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to $12 \mu\text{g}/\text{m}^3$. Figure 26-6 shows that the maximum concentration of benzene measured at BTUT is an order of magnitude less than the maximum concentration measured across the program. The annual average concentration for BTUT is just greater than the program-level average concentration and third quartile.
- Figure 26-7 presents the box plot for 1,3-butadiene. Note that the program-level maximum 1,3-butadiene concentration ($21.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to $1.5 \mu\text{g}/\text{m}^3$. Figure 26-7 shows that the program-level average is greater than the program-level third quartile, indicating that concentrations at the upper end of the concentration range are driving the program average upward. The

annual average concentration for BTUT is similar to the program-level third quartile. There were three non-detects of 1,3-butadiene measured at BTUT in 2013.

- Figure 26-8 presents the box plot for carbon tetrachloride. Similar to benzene and 1,3-butadiene, the program-level maximum concentration ($23.7 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot as the scale has been reduced to $2 \mu\text{g}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. The minimum carbon tetrachloride concentration measured at BTUT is the second lowest concentration of this pollutant measured across the program. The annual average concentration of carbon tetrachloride for BTUT is just less than the program-level first quartile and is the lowest annual average concentration among NMP sites sampling this pollutant, although the range of averages is relatively small for most of the sites.
- Figure 26-9 presents the box plot for *p*-dichlorobenzene. Note that the program-level first and second quartiles are both zero and therefore not visible on the box plot. The maximum *p*-dichlorobenzene concentration measured at BTUT is the maximum concentration measured across the program, although more than half of the measurements collected at BTUT were non-detects. The annual average concentration for BTUT is just greater than the program-level average concentration and ranks 10th highest among NMP sampling this pollutant.
- Figure 26-10 is the box plot for 1,2-dichloroethane. Similar to other pollutants, the program-level maximum concentration ($111 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot as the scale has been reduced to $1 \mu\text{g}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. The program-level average concentration is more than twice the program third quartile for this pollutant and is greater than the maximum concentration measured at most sites sampling 1,2-dichloroethane. This is because the program-level average is being driven by the higher measurements collected at a few monitoring sites. Figure 26-10 shows that the maximum 1,2-dichloroethane concentration measured at BTUT is greater than the program-level average concentration (BTUT is the only non-Calvert City, Kentucky site for which this is true) but is still half the scale of the box plot. The annual average concentration for BTUT is similar to the program-level third quartile and ranks sixth highest among NMP sites sampling this pollutant. Fifteen non-detects of 1,2-dichloroethane were measured at BTUT.
- Although the maximum dichloromethane concentration across the program was measured at BTUT ($5,604 \mu\text{g}/\text{m}^3$), the scale of the box plot in Figure 26-11 was reduced, although the first, second, and third quartiles are still relatively unclear. What is clear, though is that a high percentage of the dichloromethane concentrations measured across the program fall below the minimum concentration measured at BTUT. As discussed in the previous section, dichloromethane concentrations measured at BTUT account for all but one of the 12 measurements greater than $100 \mu\text{g}/\text{m}^3$ across the program. The maximum dichloromethane concentration measured at BTUT is more than 20 times the next

highest concentration measured at another NMP site. Concentrations of dichloromethane measured at BTUT typically run high compared to other NMP sites, but concentrations measured in 2013 are particularly high compared to past years. The program-level average concentration ($8.17 \mu\text{g}/\text{m}^3$) is an order of magnitude greater than third quartile ($0.90 \mu\text{g}/\text{m}^3$), indicating that while most of the dichloromethane concentrations measured across the program are less than $1 \mu\text{g}/\text{m}^3$, the concentrations at the upper end of the range are driving that program-level average. BTUT is the only site for which dichloromethane is a pollutant of interest and has the highest annual average concentration of dichloromethane among sites sampling this pollutant (the annual average concentration for BTUT is 15 times greater than the next highest annual average for an NMP sites sampling VOCs).

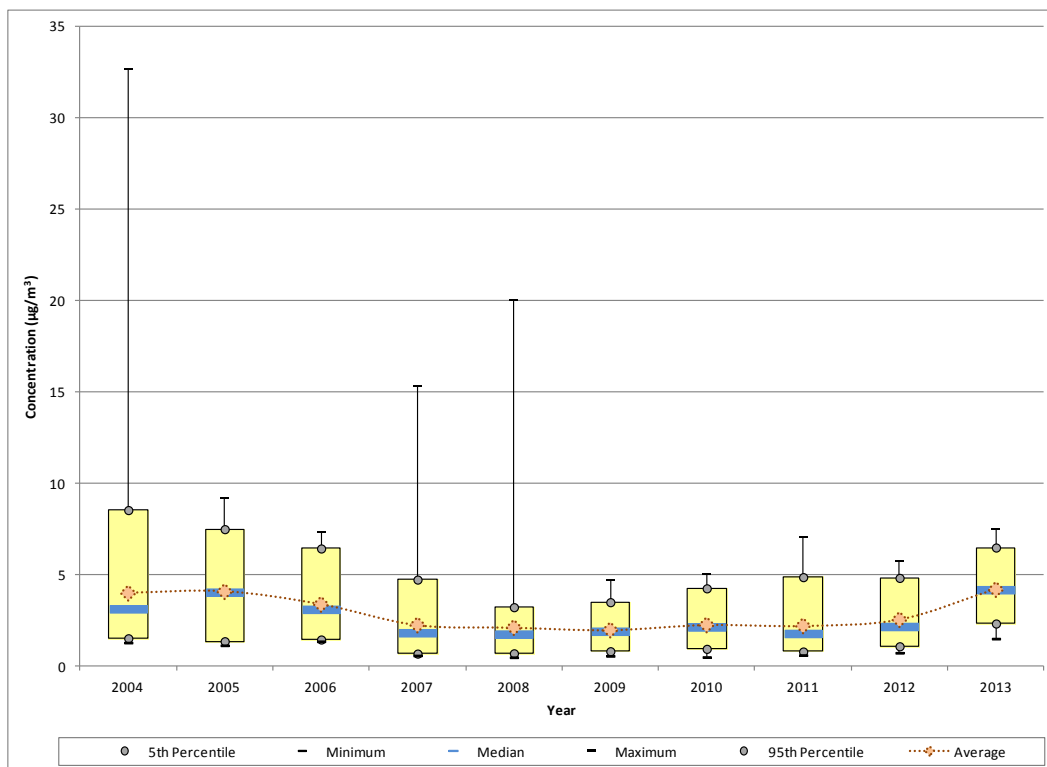
- Similar to many of the other VOCs, the program-level maximum ethylbenzene concentration ($18.7 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot in Figure 26-12 as the scale has been reduced to $6 \mu\text{g}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. This figure shows that the program-level average concentration is similar to the program-level third quartile, both of which are less than the annual average ethylbenzene concentration for BTUT. The annual average ethylbenzene concentration for BTUT is the fifth highest annual average concentration among NMP sites sampling this pollutant.
- Figure 26-13 shows that the annual average formaldehyde concentration for BTUT is nearly three times greater than the program-level average and more than twice the program-level third quartile. As discussed in the previous section, BTUT has the highest annual average formaldehyde concentration among NMP sites sampling carbonyl compounds. The minimum concentration measured at BTUT is just less than the program-level median concentration, meaning that nearly half of the formaldehyde concentrations measured across the program are less than BTUT's minimum formaldehyde concentration. Even though the maximum formaldehyde concentration was not measured at BTUT, this site has the greatest number of formaldehyde concentrations greater than $10 \mu\text{g}/\text{m}^3$ among NMP sites sampling carbonyl compounds (15, compared eight for GPCO and two or less for four additional sites).
- Figure 26-14 is the box plot for naphthalene, which shows that the annual average naphthalene concentration for BTUT is less than the program-level average concentration and similar to the program-level median concentration. The annual average concentration of naphthalene for BTUT ranks 17th among the 22 sites for which annual averages could be calculated.
- Figure 26-15 is the box plot for nickel (PM_{10}). The maximum concentration of nickel measured at BTUT is about one-quarter of the program-level maximum concentration. The annual average concentration of nickel for BTUT is greater than the program-level average concentration and just greater than the program-level third quartile. The minimum concentration of nickel measured at BTUT is just less than the program-level first quartile.

- Figure 26-16 shows that concentrations of propionaldehyde measured at BTUT are on the higher end of the concentration range, as the entire range of concentrations measured at BTUT is greater than the program-level median concentration. BTUT is one of only two NMP sites for which propionaldehyde is a pollutant of interest and has the highest annual average concentration of this pollutant among NMP sites sampling carbonyl compounds. The annual average propionaldehyde concentration for BTUT is twice the program-level average concentration, although the maximum propionaldehyde concentration was not measured at BTUT.

26.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. BTUT has sampled carbonyl compounds, VOCs, metals, and SNMOCs under the NMP since 2003 and PAHs since 2008. Thus, Figures 26-17 through 26-29 present the 1-year statistical metrics for each of the pollutants of interest for BTUT. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

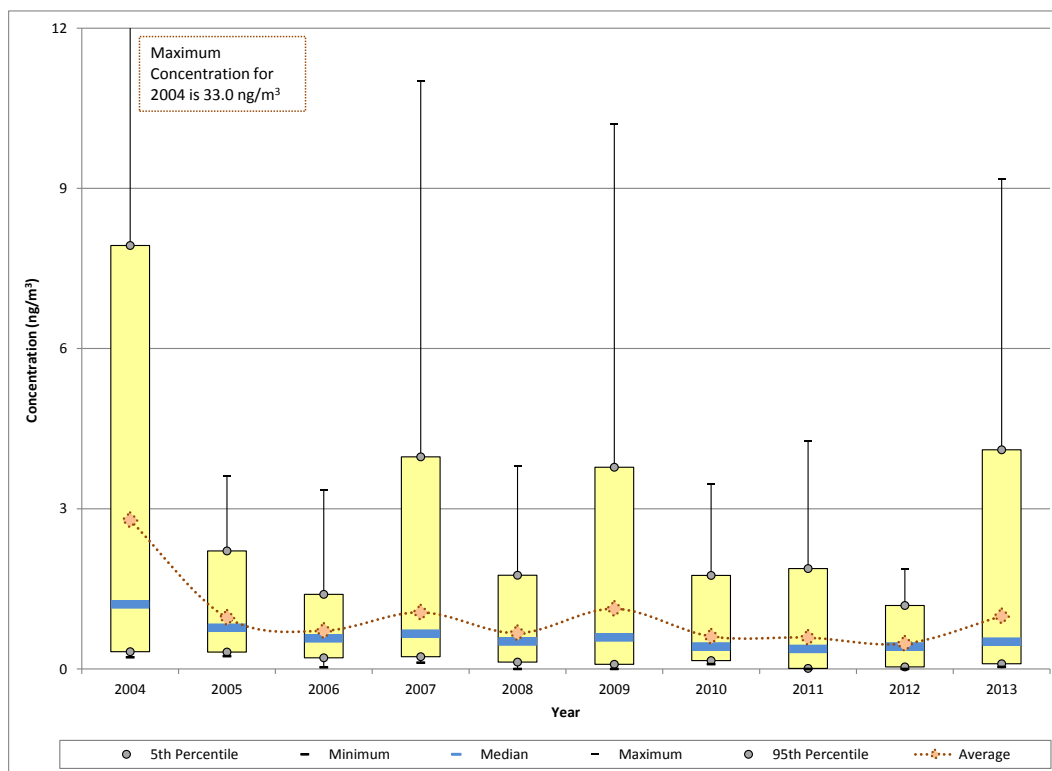
Figure 26-17. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at BTUT



Observations from Figure 26-17 for acetaldehyde measurements collected at BTUT include the following:

- Sampling for carbonyl compounds under the NMP began at BTUT in late July 2003. Because this represents less than half of the sampling year, Figure 26-17 excludes data from 2003.
- The maximum acetaldehyde concentration was measured in 2004 ($32.7 \mu\text{g}/\text{m}^3$). The next highest concentrations of acetaldehyde were measured at BTUT in 2008 ($20.0 \mu\text{g}/\text{m}^3$) and 2007 ($15.3 \mu\text{g}/\text{m}^3$). No acetaldehyde concentrations greater than $8 \mu\text{g}/\text{m}^3$ have been measured at BTUT since 2005.
- After 2005, the 1-year average concentration exhibits a steady decreasing trend through 2009, when the 1-year average concentration reaches a minimum ($1.97 \mu\text{g}/\text{m}^3$), although the most significant changes occurred between 2005 and 2007. Between 2007 and 2011, the 1-year average concentration varied by less than $0.30 \mu\text{g}/\text{m}^3$, ranging from $1.97 \mu\text{g}/\text{m}^3$ (2009) to $2.25 \mu\text{g}/\text{m}^3$ (2010).
- Although the range of concentrations measured in 2012 is smaller than the range measured in 2011, a slight increase is shown in both the 1-year average and median concentrations for 2012. This slight increase is followed by a significant increase for 2013, when both the 1-year average and median concentrations are at a maximum for the period of sampling.

Figure 26-18. Yearly Statistical Metrics for Arsenic (PM₁₀) Concentrations Measured at BTUT



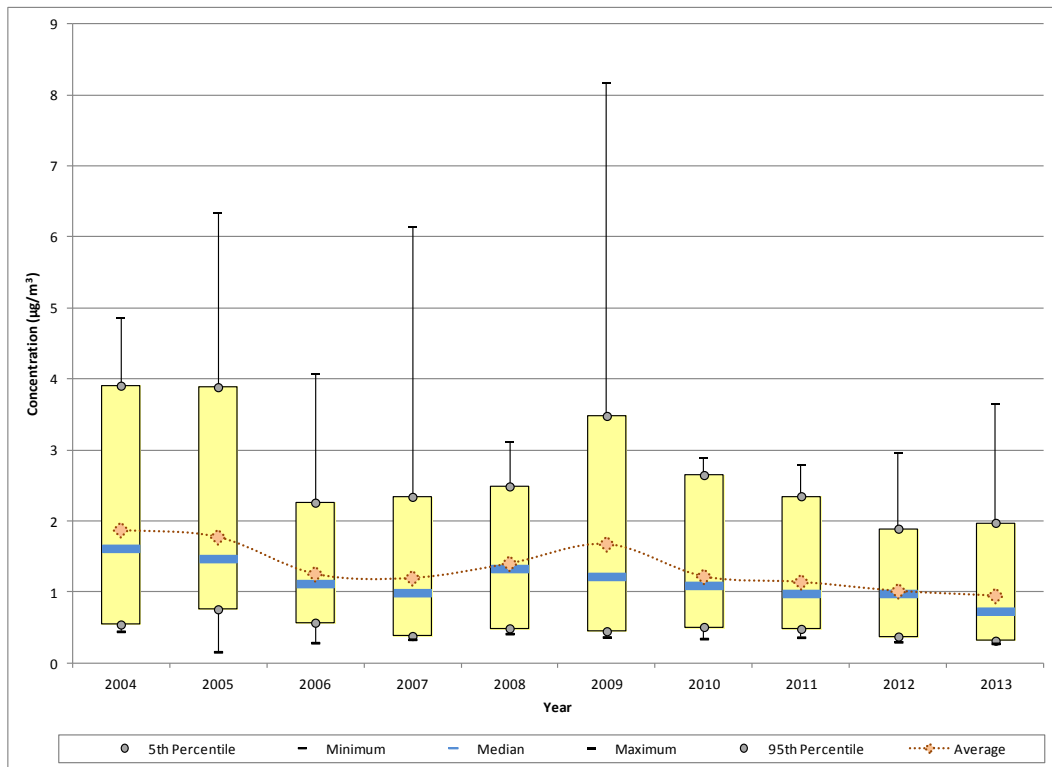
Observations from Figure 26-18 for arsenic measurements collected at BTUT include the following:

- Sampling for PM₁₀ metals under the NMP began at BTUT in late July 2003. Because this represents less than half of the sampling year, Figure 26-18 excludes data from 2003.
- The maximum arsenic concentration was measured at BTUT in 2004 (33.0 ng/m³) and is nearly twice the next highest concentration (16.8 ng/m³), also measured in 2004. The three highest measurements of arsenic were all measured at BTUT in 2004; further, eight of the 14 highest concentrations of arsenic (those greater than 5 ng/m³) were measured in 2004.
- Of the 24 highest arsenic concentrations measured at BTUT, 13 were measured during the first quarter of the calendar year and 11 were measured during the fourth quarter of the calendar year, suggesting a seasonality in the measurements.
- The average concentration of arsenic decreased significantly from 2004 to 2005, with the 1-year average decreasing from 2.79 ng/m³ to 0.96 ng/m³. Between 2006 and 2010, there is an undulating pattern in the 1-year average concentrations, with years with higher concentrations followed by years with lower concentrations. During this period, the 1-year average arsenic concentration fluctuated between 0.61 ng/m³ (2010) and 1.13 ng/m³ (2009). However, the statistical parameters for 2007 and 2009 are being driven primarily by a single “high” measurement. If the maximum

concentrations measured in 2007 and 2009 were removed from the data sets, the 1-year average concentrations for this period would all be less than 1 ng/m³.

- The smallest range of arsenic concentrations was measured at BTUT in 2012, when the 1-year average concentration is at a minimum. The maximum arsenic concentration measured in 2012 is less than 2 ng/m³, the only year for which this is true, and is less than the 95th percentile for several other years of sampling.
- Concentrations of arsenic measured at BTUT increased significantly for 2013, as indicated by the increase shown in all of the statistical parameters. Although the 1-year average concentration doubled from 2012 to 2013, the increase in the median concentration is less dramatic.

Figure 26-19. Yearly Statistical Metrics for Benzene Concentrations Measured at BTUT

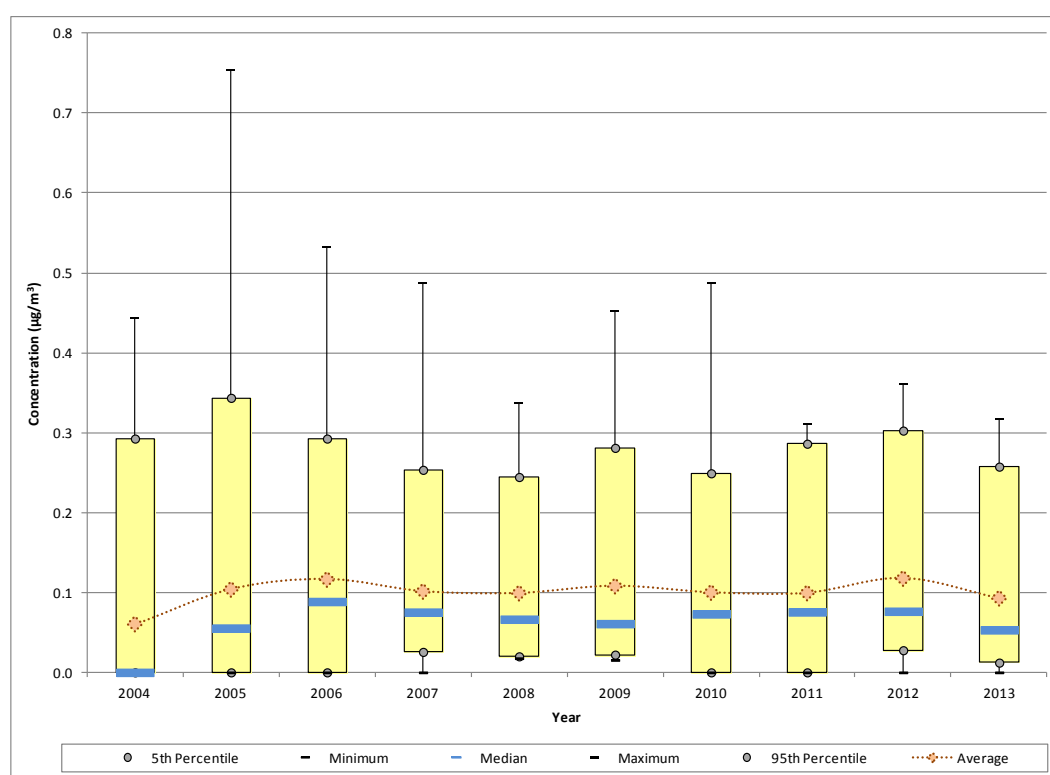


Observations from Figure 26-19 for benzene measurements collected at BTUT include the following:

- Sampling for VOCs under the NMP began at BTUT in late July 2003. Because this represents less than half of the sampling year, Figure 26-19 excludes data from 2003.
- The maximum concentration of benzene shown was measured in 2009 (8.16 µg/m³). The next highest concentration (6.56 µg/m³) was also measured in 2009, although concentrations greater than 6 µg/m³ were also measured in 2005 and 2007.

- Concentrations of benzene appear to be higher during the colder months of the year, as 50 of the 54 highest concentrations (those greater than $2.50 \mu\text{g}/\text{m}^3$) were measured during the first (28) or fourth (22) quarters of the calendar year.
- The 1-year average and median benzene concentrations have a decreasing trend through 2007. An increasing trend in the 1-year average concentration is then shown through 2009, after which another decreasing trend follows. The 1-year average benzene concentration is at a minimum for 2013 ($0.95 \mu\text{g}/\text{m}^3$), the first time since the onset of sampling that the 1-year average concentration is less than $1 \mu\text{g}/\text{m}^3$. The median concentration exhibits a similar trend, except it did not exhibit the same increase for 2009 as the 1-year average concentration.

Figure 26-20. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at BTUT



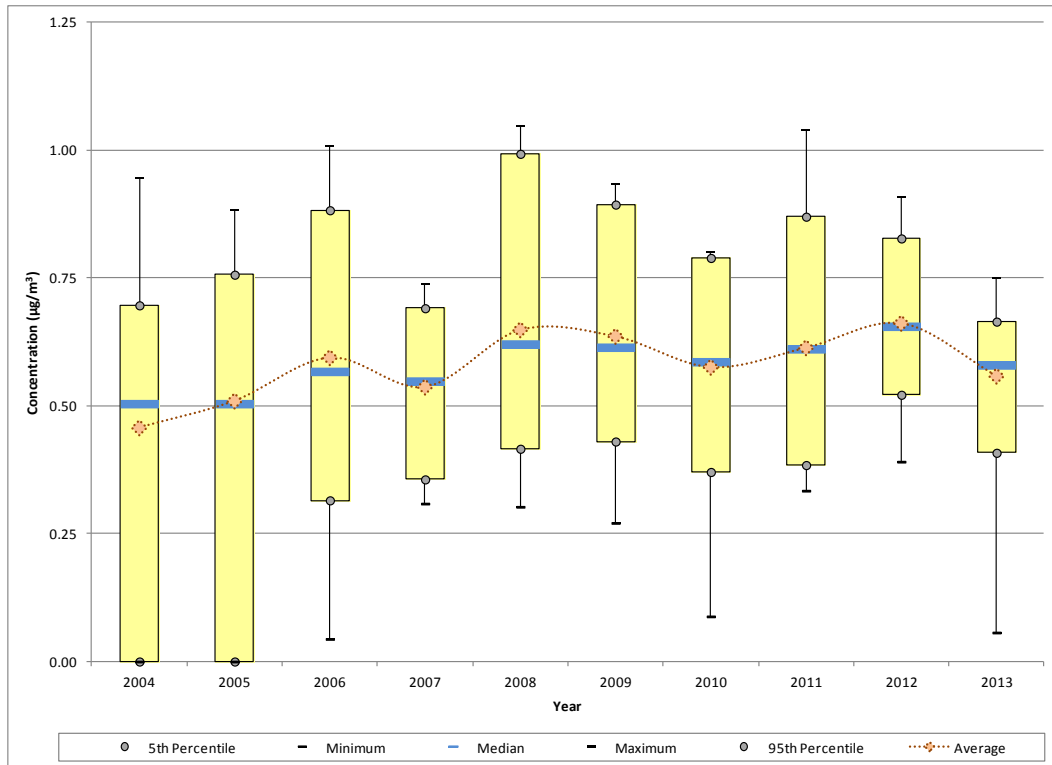
Observations from Figure 26-20 for 1,3-butadiene measurements collected at BTUT include the following:

- The maximum concentration of 1,3-butadiene shown was measured in 2005 ($0.75 \mu\text{g}/\text{m}^3$). The second highest concentration was also measured in 2005 ($0.53 \mu\text{g}/\text{m}^3$), although a similar measurement was also collected in 2006. These are the only concentrations of 1,3-butadiene greater than $0.5 \mu\text{g}/\text{m}^3$ measured at BTUT.
- The minimum, 5th percentile, and median concentrations are all zero for 2004, indicating that at least half of the measurements were non-detects. The detection rate of 1,3-butadiene increased after 2004, as indicated by the increase in the median

concentrations for 2005 and 2006 and then the 5th percentile for 2007. The percentage of non-detects decreased from 75 percent for 2004 to 0 percent for 2008 and 2009. The percentage of non-detects increased to 7 percent for 2010 and 18 percent for 2011, explaining why the 5th percentile returned to zero. There was a single non-detect of this pollutant in 2012 and three in 2013.

- The 1-year average concentration increased from 0.061 $\mu\text{g}/\text{m}^3$ for 2004 to 0.104 $\mu\text{g}/\text{m}^3$ for 2005. This increase is likely due to the decrease in non-detects (and thus zeros substituted for them) as well as the higher concentrations measured in 2005, as discussed above. Between 2005 and 2013, the 1-year average concentration has changed little, ranging from 0.093 $\mu\text{g}/\text{m}^3$ (2013) to 0.118 $\mu\text{g}/\text{m}^3$ (2012). The median concentration varies a little more, although both the 1-year average and median concentrations are at a minimum for 2013.

Figure 26-21. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at BTUT

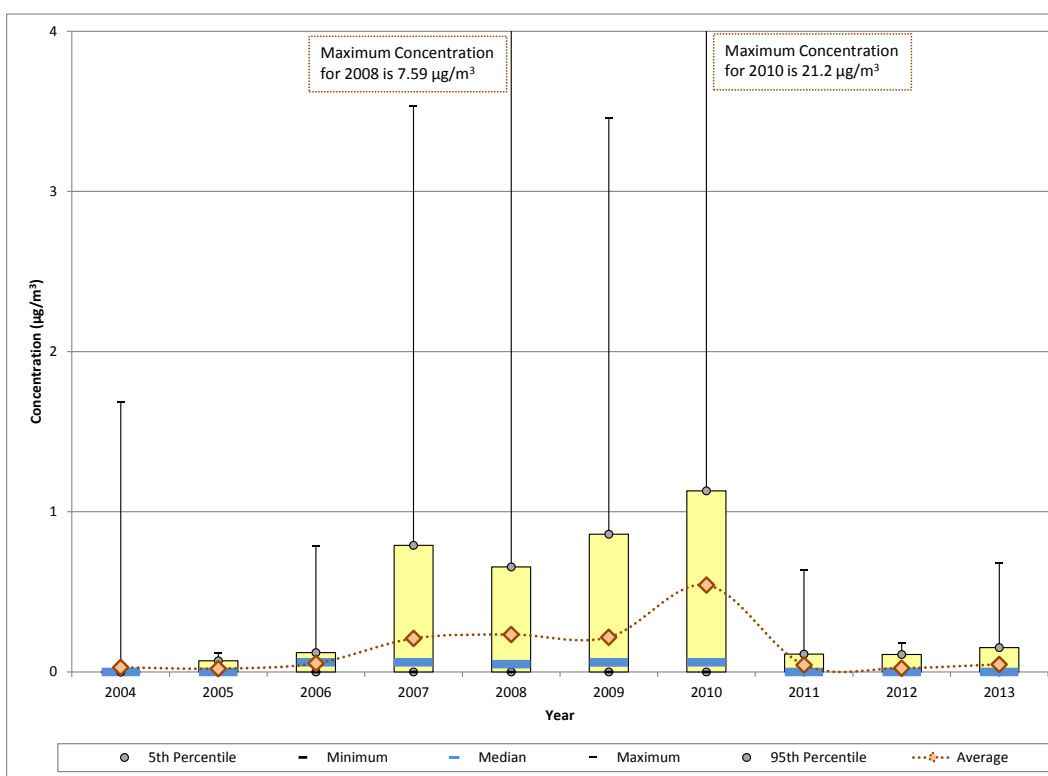


Observations from Figure 26-21 for carbon tetrachloride measurements collected at BTUT include the following:

- Non-detects of carbon tetrachloride were measured only in 2004 (nine) and 2005 (five). Concentrations of carbon tetrachloride greater than 1 $\mu\text{g}/\text{m}^3$ were measured in 2006 (two), 2008 (three), and 2011 (one).

- A significant increasing trend is shown in the 1-year average concentrations between 2004 and 2008, with the exception of 2007. The range and magnitude of concentrations measured decreased substantially for 2007, which is reflected in the dip in the 1-year average concentration. A slight decreasing trend in the carbon tetrachloride measurements is shown between 2008 and 2010, after which an increasing trend is shown through 2012.
- A significant decrease in the 1-year average concentration, and the other statistical parameters, is shown for 2013. This year has the lowest maximum concentration since 2007 and the lowest minimum concentration since 2006. In addition, the difference between the 5th and 95th percentiles, or the range within which a majority of concentrations fall, is also at a minimum for 2013.

Figure 26-22. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at BTUT



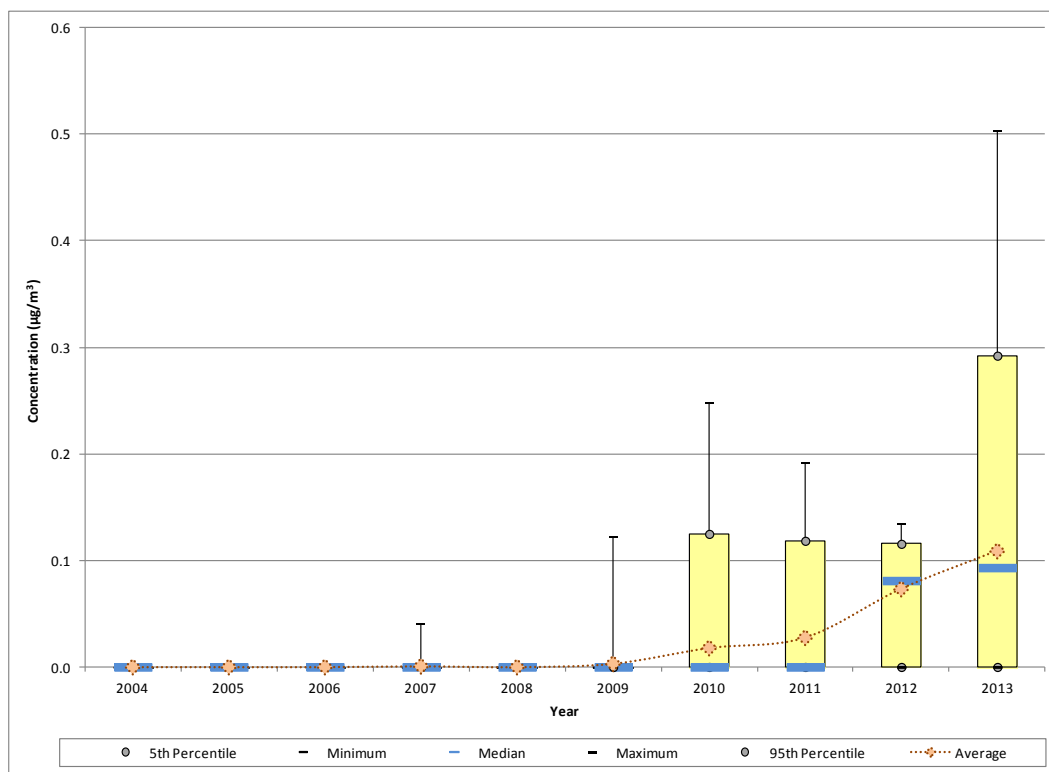
Observations from Figure 26-22 for *p*-dichlorobenzene measurements collected at BTUT include the following:

- The minimum, 5th percentile, and median concentrations are all zero for 2004 and 2005, indicating that at least half of the measurements were non-detects. In 2004, all but one measurement was a non-detect. The detection rate of *p*-dichlorobenzene then increased each year through 2008 when the fewest non-detects were measured (nine). The percentage of non-detects has then increased each year since, reaching a secondary maximum for 2013 (63 percent of measurements were non-detects in 2013, the most

since 2005), explaining why the median concentration returned to zero for 2011, 2012, and 2013.

- The maximum *p*-dichlorobenzene concentration measured at BTUT was measured in 2010 (21.2 $\mu\text{g}/\text{m}^3$) and is nearly three times greater than the next highest concentration measured (7.59 $\mu\text{g}/\text{m}^3$, measured in 2008). In all, only 12 concentrations greater than 1 $\mu\text{g}/\text{m}^3$ have been measured at BTUT, all of which were measured prior to 2011.
- The increases shown for several of the statistical parameters between 2007 and 2010, particularly the maximum, 95th percentile, and 1-year average concentrations, are a result of the increased detection rate combined with the higher concentrations measured.

Figure 26-23. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at BTUT



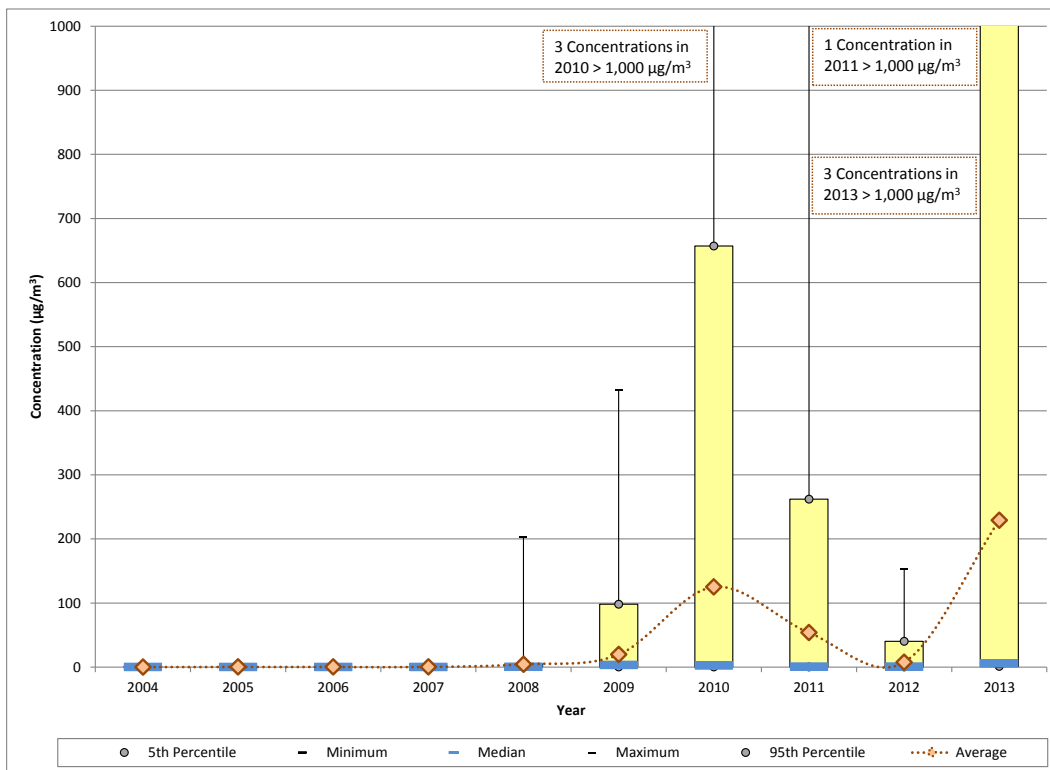
Observations from Figure 26-23 for 1,2-dichloroethane measurements collected at BTUT include the following:

- For the first several years of sampling, all of the statistical parameters shown were zero. Between 2004 and 2008, there was a single measured detection of 1,2-dichloroethane, which was measured in 2007. Beginning with 2009, the number of measured detections began to increase; there were two in 2009, seven in 2010, 15 in 2011, 47 in 2012, and 37 in 2013. This explains the increases shown in the 1-year average concentrations (as well as other statistical parameters) for 2010 through 2013.

The first year with a median concentration greater than zero is 2012. This indicates that there were more measured detections than non-detects for the first time since the onset of sampling.

- The range of concentrations measured in 2013 is considerably larger than the range of concentrations measured in previous years, as the 1-year average concentration for 2013 is similar to the 95th percentile shown for previous years. All seven of the 1,2-dichloroethane concentrations greater than $0.25 \mu\text{g}/\text{m}^3$ measured at BTUT were measured in 2013. Further, measurements collected in 2013 account for more than one-third of the concentrations greater than $0.1 \mu\text{g}/\text{m}^3$, with another one-third measured in 2012, and the final one-third measured between 2009 and 2011.

Figure 26-24. Yearly Statistical Metrics for Dichloromethane Concentrations Measured at BTUT



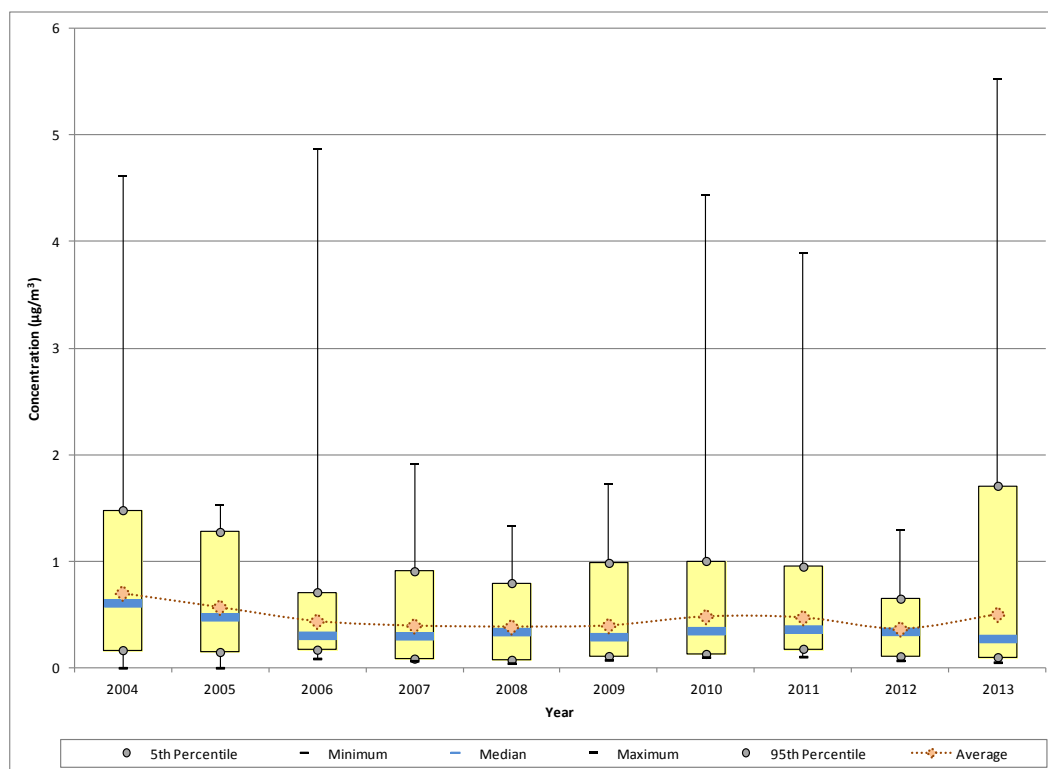
Observations from Figure 26-24 for dichloromethane measurements collected at BTUT include the following:

- Prior to 2008, the maximum concentration of dichloromethane measured at BTUT was $1.64 \mu\text{g}/\text{m}^3$ (in 2005). However, due to the scale on the graph, none of the statistical parameters for the early years are visible.
- Beginning in 2008, “higher” concentrations of dichloromethane began to be measured at BTUT. In 2008, the first concentration greater than $100 \mu\text{g}/\text{m}^3$ was measured ($203 \mu\text{g}/\text{m}^3$). In 2009, four concentrations greater than $100 \mu\text{g}/\text{m}^3$ were measured. In

2010, three dichloromethane concentrations greater than 1,000 $\mu\text{g}/\text{m}^3$ were measured, along with six more greater than 100 $\mu\text{g}/\text{m}^3$. For 2011, there was only one concentration greater than 1,000 $\mu\text{g}/\text{m}^3$ measured, along with four more greater than 100 $\mu\text{g}/\text{m}^3$. For 2012 only one concentration greater than 100 $\mu\text{g}/\text{m}^3$ was measured. The maximum dichloromethane concentration was measured at BTUT in 2013 (5,604 $\mu\text{g}/\text{m}^3$) along with two others greater than 1,000 $\mu\text{g}/\text{m}^3$ and eight others greater than 100 $\mu\text{g}/\text{m}^3$.

- There does not appear to be a pattern in the time of year that these higher measurements are collected. Of the 32 concentrations measured at BTUT greater than 100 $\mu\text{g}/\text{m}^3$, at least one has been measured in each month of the year except March, April, and May. However, the majority of them have been measured during the second half of any given year (23 of 32). August and September tie for the month with the greatest number of these higher measurements (6 each), although January and December tie for second place (5 each).
- Each of the statistical parameters is at a maximum for 2013. Concentrations measured in 2013 span four orders of magnitude (0.585 $\mu\text{g}/\text{m}^3$ to 5,604 $\mu\text{g}/\text{m}^3$), although 2013 is not the only year for which this is true.

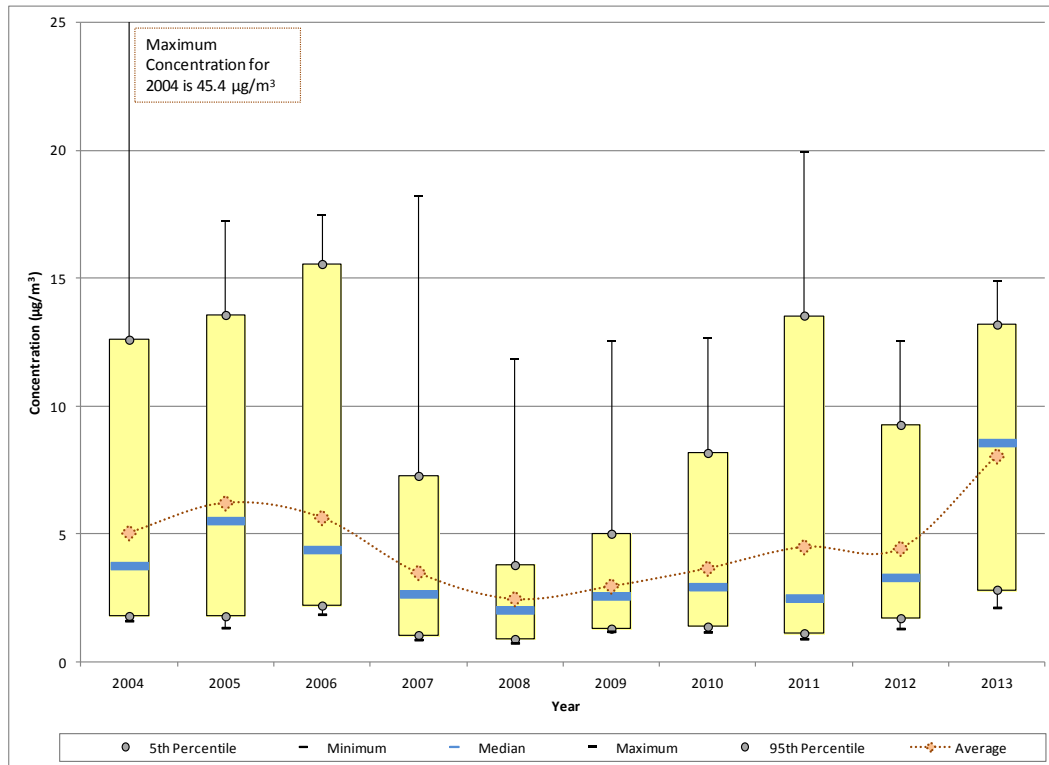
Figure 26-25. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at BTUT



Observations from Figure 26-25 for ethylbenzene measurements collected at BTUT include the following:

- The maximum concentration of ethylbenzene measured at BTUT was measured in 2013 ($5.53 \mu\text{g}/\text{m}^3$) and is the only concentration greater than $5 \mu\text{g}/\text{m}^3$ measured at this site. In total, only seven concentrations greater than $2 \mu\text{g}/\text{m}^3$ have been measured at BTUT (of which three were measured in 2013).
- A steady decreasing trend in the 1-year average concentration is shown from 2004 through 2007, representing just less than a 50 percent decrease (from $0.70 \mu\text{g}/\text{m}^3$ for 2004 to $0.39 \mu\text{g}/\text{m}^3$ for 2007). However, most of the change is realized between 2004 and 2006.
- Between 2007 and 2009, little change is shown, with the 1-year average concentrations varying by less than $0.012 \mu\text{g}/\text{m}^3$.
- Nearly all of the statistical parameters exhibit increases for 2010, particularly the maximum concentration. However, removing the maximum concentration from the data set would result in a 1-year average concentration similar to those shown for 2007 through 2009. This is also true for 2011.
- The range of ethylbenzene concentrations measured in 2012 is the smallest among the years of sampling and the 1-year average concentration is at a minimum. Conversely, the largest range of concentrations was measured in 2013 and the 1-year average concentration is at its highest since 2005. The range within which the majority of concentrations fall, as indicated by the 5th and 95th percentiles is also at its largest for 2013, yet the median concentration is at a minimum for this year. Even with the higher measurements collected, 2013 has the fewest number of measurements greater than $0.25 \mu\text{g}/\text{m}^3$.

Figure 26-26. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at BTUT

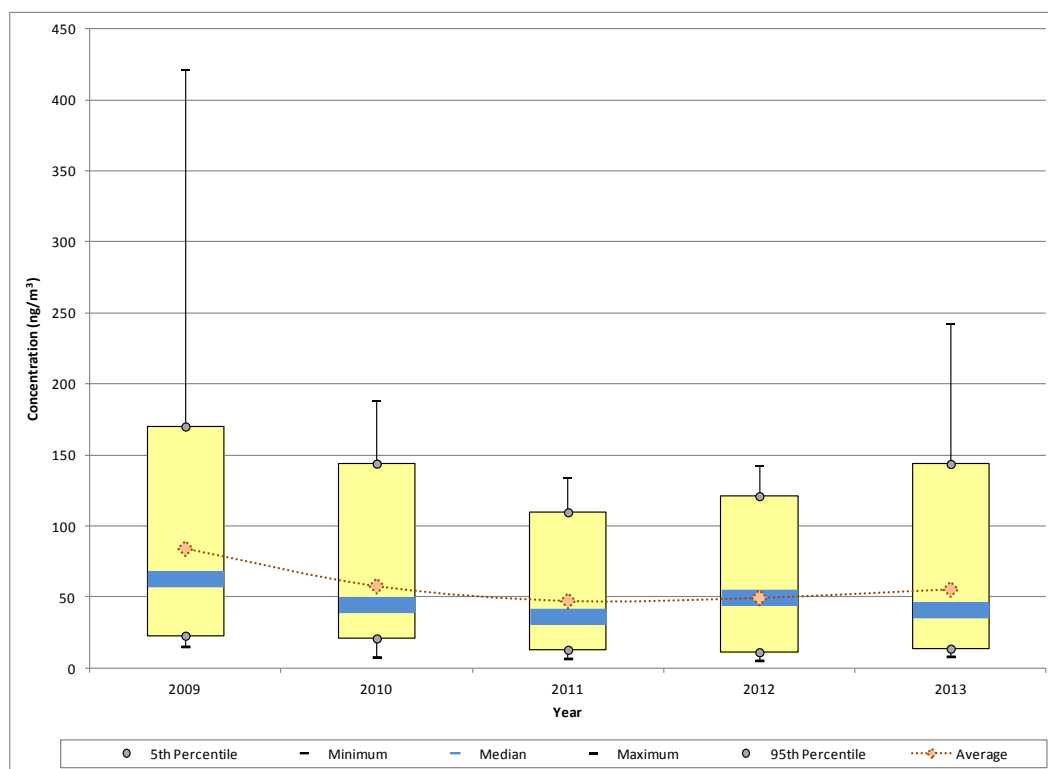


Observations from Figure 26-26 for formaldehyde measurements collected at BTUT include the following:

- The maximum formaldehyde concentration (45.4 µg/m³) was measured on August 31, 2004, on the same day as the highest acetaldehyde concentration. This measurement is more than twice the next highest concentration (19.9 µg/m³), measured in 2011. Concentrations greater than 15 µg/m³ were measured 12 times between 2004 and 2007, plus three additional times in 2011.
- Although the maximum concentration decreased significantly from 2004 to 2005, the other statistical metrics exhibit increases for 2005. The median increased by nearly 2 µg/m³ from 2004 to 2005, indicating that concentrations ran higher in 2005 than 2004 (as opposed to being driven by an outlier, as in 2004). As an illustration, there were 11 concentrations greater than 5 µg/m³ measured in 2004 compared to 31 in 2005.
- After 2005, the 1-year average concentration began to decrease, reaching a minimum for 2008. In 2008, 95 percent of the concentrations were less than 4 µg/m³, which is less than the 1-year average and/or median concentrations for some of the previous years. After 2008, a steady increasing trend is shown in the 1-year average formaldehyde concentrations, as well as most other statistical parameters. This trend, however, levels out for 2012.

- Although little change is shown in the 1-year average concentration between 2011 and 2012, the range of concentrations measured is smaller for 2012 and the median exhibits an increase. The decrease in the concentrations at the upper end of the range from 2011 to 2012 are balanced out by a higher number of measurements at the mid-to-upper part of the range. The number of measurements greater than $10 \mu\text{g}/\text{m}^3$ decreased from nine to one from 2011 to 2012 while the number of measurements between $5 \mu\text{g}/\text{m}^3$ and $10 \mu\text{g}/\text{m}^3$ increased from six to 14 during the same period. In addition, there are six concentrations measured in 2011 that are less than the minimum concentration measured in 2012; thus, the concentrations at the lower end of the concentration range increased for 2012.
- For 2013, the 1-year average concentration nearly doubled and the median concentration increased by 159 percent. Although no formaldehyde concentrations greater than $15 \mu\text{g}/\text{m}^3$ were measured in 2013, this year has the highest number of concentrations greater than $10 \mu\text{g}/\text{m}^3$ (16) and concentrations greater than $5 \mu\text{g}/\text{m}^3$ account for more than 75 percent of the measurements in 2013. This is also the only year for which a formaldehyde concentration less than $2 \mu\text{g}/\text{m}^3$ was not measured.

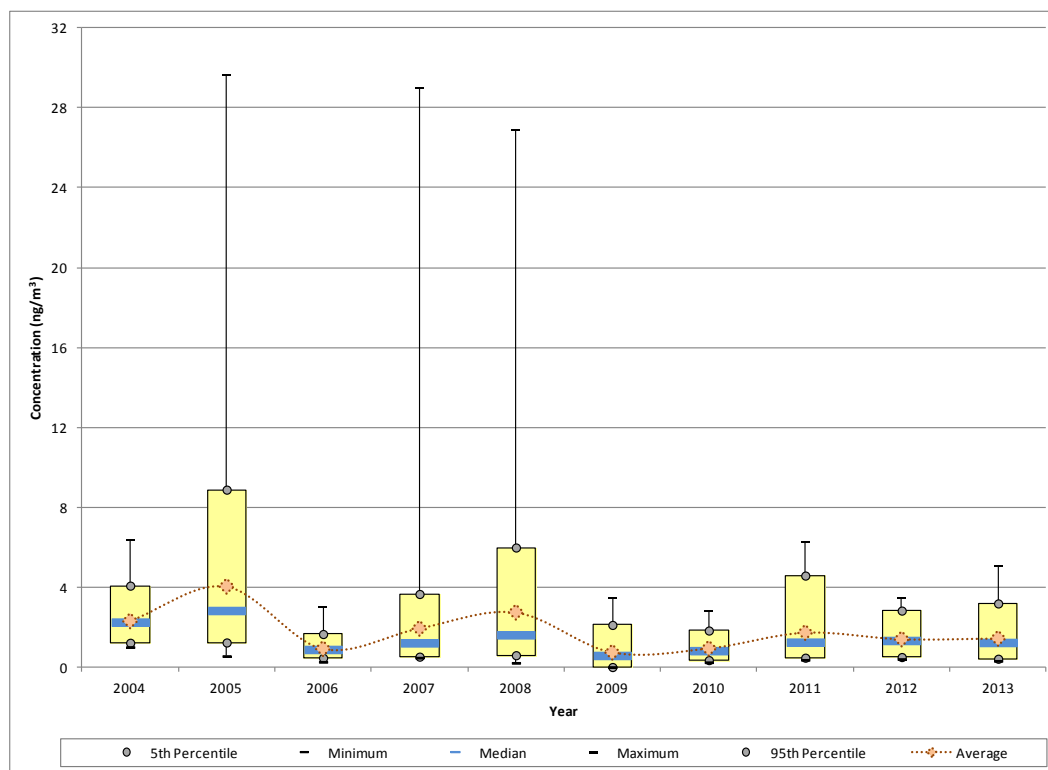
Figure 26-27. Yearly Statistical Metrics for Naphthalene Concentrations Measured at BTUT



Observations from Figure 26-27 for naphthalene measurements collected at BTUT include the following:

- Although PAH sampling began at BTUT in April 2008, complications with the sampler lead to a 6-month lapse in sampling until mid-October. Thus, Figure 26-27 begins with 2009.
- The maximum naphthalene concentration (421 ng/m^3) was measured in 2009. The second highest naphthalene concentration (242 ng/m^3), measured in 2013, is the only other naphthalene measurement greater than 200 ng/m^3 measured since the onset of PAH sampling at BTUT.
- A steady decreasing trend in naphthalene concentrations measured at BTUT is shown through 2011, with little change shown for 2012.
- Concentrations increased slightly for 2013, with the 95th percentile for 2013 greater than the maximum concentrations measured for the two previous years.
- Concentrations of naphthalene exhibit seasonality. Of the 45 naphthalene concentrations greater than 100 ng/m^3 measured at BTUT since 2009, all but three were measured during the first or fourth quarters of any given year, with the majority measured in January (15), November (10), or December (14).

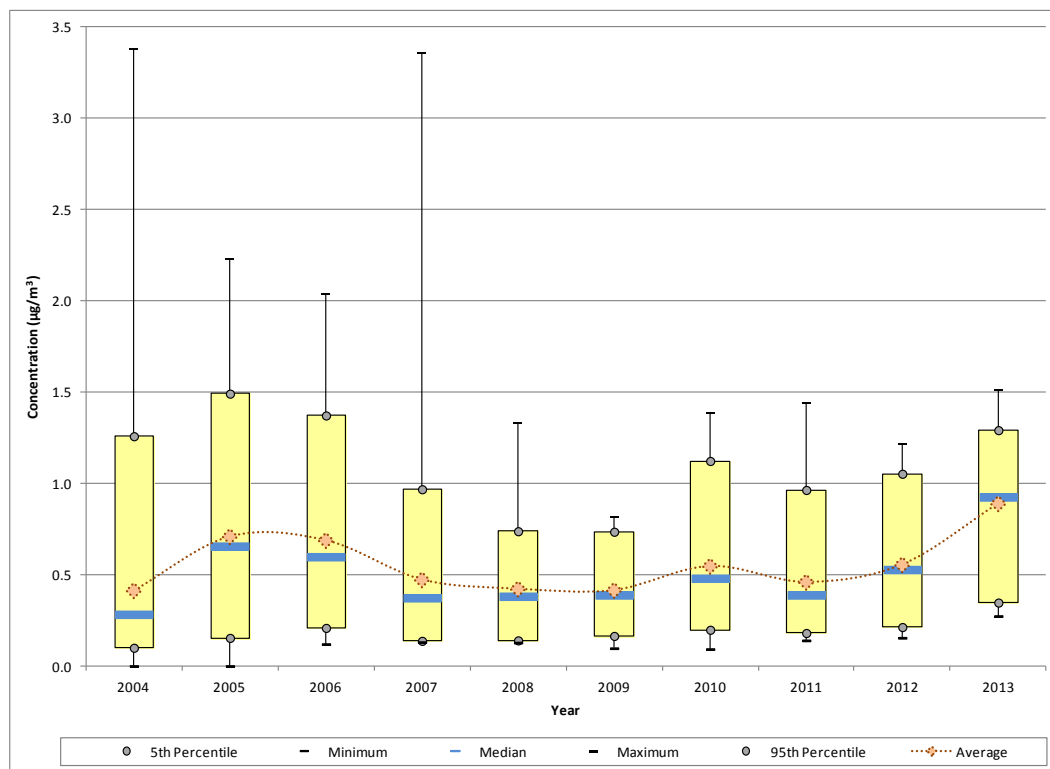
Figure 26-28. Yearly Statistical Metrics for Nickel (PM_{10}) Concentrations Measured at BTUT



Observations from Figure 26-28 for nickel measurements collected at BTUT include the following:

- The maximum nickel concentration was measured in 2005 (29.6 ng/m³), although a similar concentration was also measured in 2007. Two additional nickel concentrations greater than 20 ng/m³ were measured in 2008. No other nickel concentrations greater than 10 ng/m³ have been measured at BTUT.
- All 24 non-detects of nickel were measured in 2009 and, with one exception, were measured on consecutive sample days between June and October.
- The range of nickel concentrations measured each year is highly variable. Concentrations measured over a given year have spanned a little as 2.5 ng/m³ (2010) or up to nearly 30 ng/m³ (2005). This variability is reflected in the undulating pattern shown in the central tendency statistics, particularly in the years between 2004 and 2011. During this time period, the 1-year average concentrations ranged from 0.75 ng/m³ (2009) to 4.05 ng/m³ (2005). The concentrations measured between 2011 and 2013 exhibit less variability.

Figure 26-29. Yearly Statistical Metrics for Propionaldehyde Concentrations Measured at BTUT



Observations from Figure 26-29 for propionaldehyde measurements collected at BTUT include the following:

- The maximum propionaldehyde concentration ($3.38 \mu\text{g}/\text{m}^3$) was measured on the same day as the maximum acetaldehyde and formaldehyde concentrations (August 31, 2004), although a similar concentration was also measured in 2007. No other propionaldehyde concentrations greater than $2.5 \mu\text{g}/\text{m}^3$ have been measured at BTUT. All but one of the nine concentrations greater than $1.5 \mu\text{g}/\text{m}^3$ were measured prior to 2007, with the exception measured in 2013.
- Even though the maximum concentration decreased from 2004 to 2005, the other statistical metrics exhibit increases (similar to the formaldehyde concentrations). The median concentration more than doubled from 2004 to 2005, indicating that concentrations ran higher in 2005 than 2004 (as opposed to being driven by a few higher concentrations, as in 2004). The number of concentrations greater than $0.5 \mu\text{g}/\text{m}^3$ increased nearly four-fold, from nine in 2004 to 33 in 2005, accounting for more than half of the measurements collected in 2005.
- After 2005, the propionaldehyde concentrations began to decrease, reaching a minimum for 2009, when all of the measurements are less than $1 \mu\text{g}/\text{m}^3$. The propionaldehyde concentrations measured increased significantly from 2009 to 2010, with an undulating pattern in the 1-year average concentrations developing afterward.
- Similar to acetaldehyde and formaldehyde, each of the statistical parameters exhibits an increase for 2013, with a significant increase shown for the 1-year average concentration. The most recent year of sampling has the largest number of propionaldehyde concentrations greater than $1 \mu\text{g}/\text{m}^3$ (24), nearly double the amount for the next closest year (13 each in 2005 and 2006). Further, each year of sampling has a number of concentrations less than the minimum concentration measured in 2013 ($0.27 \mu\text{g}/\text{m}^3$), from as few as six (2006) to as many as 24 (2004).

26.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the BTUT monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

26.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for BTUT and where annual average concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is

limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 26-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 26-6. Risk Approximations for the Utah Monitoring Site

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Bountiful, Utah - BTUT						
Acetaldehyde	0.0000022	0.009	55/55	4.18 ± 0.36	9.21	0.46
Benzene	0.0000078	0.03	53/53	0.94 ± 0.16	7.31	0.03
1,3-Butadiene	0.00003	0.002	50/53	0.09 ± 0.02	2.76	0.05
Carbon Tetrachloride	0.000006	0.1	53/53	0.56 ± 0.03	3.36	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	19/53	0.05 ± 0.03	0.51	<0.01
1,2-Dichloroethane	0.000026	2.4	38/53	0.11 ± 0.03	2.84	<0.01
Dichloromethane	0.000000016	0.6	53/53	225.03 ± 219.72	3.60	0.38
Ethylbenzene	0.0000025	1	53/53	0.49 ± 0.24	1.23	<0.01
Formaldehyde	0.000013	0.0098	55/55	8.05 ± 0.87	104.64	0.82
Propionaldehyde	--	0.008	55/55	0.89 ± 0.08	--	0.11
Arsenic (PM ₁₀) ^a	0.0043	0.000015	59/59	0.99 ± 0.40	4.26	0.07
Naphthalene ^a	0.000034	0.003	56/56	55.48 ± 11.39	1.89	0.02
Nickel (PM ₁₀) ^a	0.00048	0.00009	59/59	1.44 ± 0.24	0.69	0.02

-- = A Cancer URE or Noncancer RfC is not available.

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

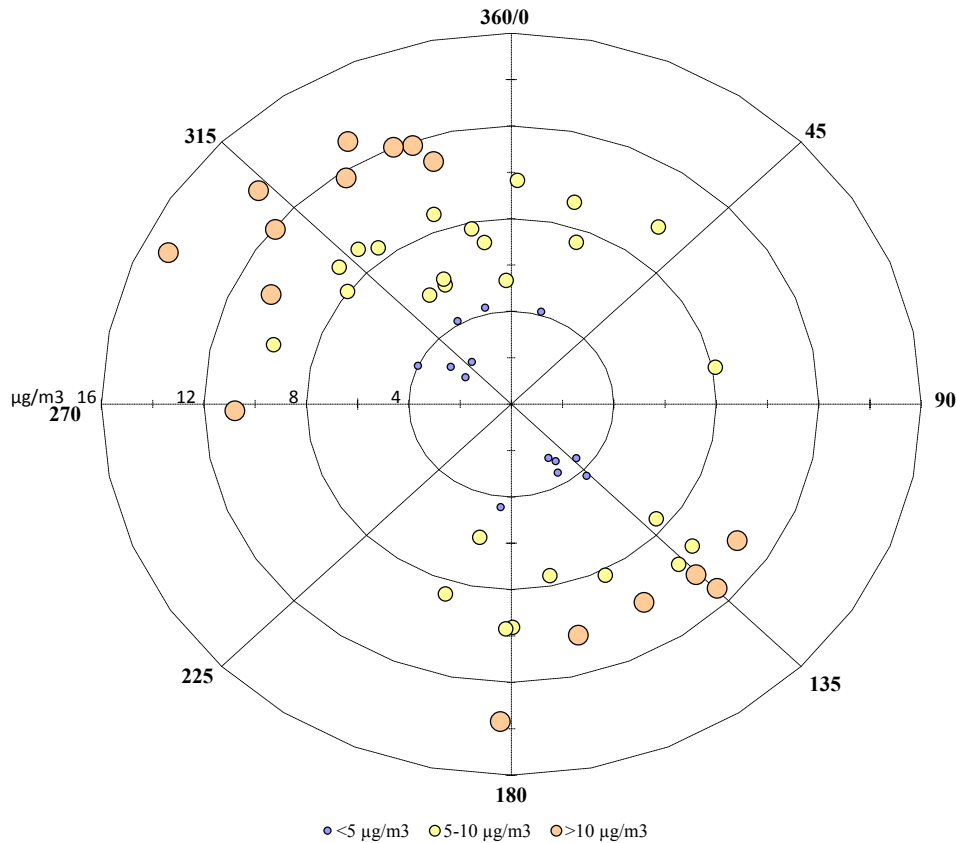
Observations for BTUT from Table 26-6 include the following:

- The pollutants with the highest annual average concentrations are dichloromethane, formaldehyde, and acetaldehyde, as discussed in Section 26.4.1.

- The pollutants with the highest cancer risk approximations are formaldehyde, acetaldehyde, and benzene. The cancer risk approximation for formaldehyde for BTUT (104.64 in-a-million) is the only cancer risk approximation greater than 100 in-a-million calculated across the program. The remaining cancer risk approximations calculated for BTUT are all less than 10 in-a-million.
- There were no pollutants of interest with noncancer hazard approximations greater than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants. The highest noncancer hazard approximation was calculated for formaldehyde (0.82), which is the highest noncancer hazard approximation calculated among the site-specific pollutants of interest with noncancer toxicity factors. The remaining noncancer hazard approximations calculated for BTUT are all less than 0.50.
- Dichloromethane's relatively high annual average concentration does not translate into high risk approximations. This is an indication of the toxicity potential of dichloromethane concentrations in ambient air.

For each of the site-specific pollutants of interest that have cancer risk approximations greater than 75 in-a-million and/or a noncancer hazard approximation greater than 1.0, a pollution rose was created to help identify the geographical area where the emissions sources of these pollutants may have originated. A pollution rose is a plot of the ambient concentration versus the wind speed and direction; high concentrations may be shown in relation to the direction of potential emissions sources. Additional information about this analysis is presented in Section 3.4.3.3. Figure 26-30 is BTUT's pollution rose for formaldehyde.

Figure 26-30. Pollution Rose for Formaldehyde Concentrations Measured at BTUT



Observations from Figure 26-30 include the following:

- The pollution rose shows that most of the formaldehyde concentrations are shown in relation to samples days with an average wind direction from the southeast to south or northwest to north. This matches the wind observations shown on the sample day wind rose presented in Figure 26-3.
- The facility map in Figure 26-2 shows that most of the point sources are located to the south and southwest of BTUT, along the I-15 corridor and towards Salt Lake City.
- Formaldehyde concentrations of varying magnitude are shown in relation to the predominant wind directions, although compared to other NMP sites, even the lowest concentrations measured at BTUT are higher than half the measurements collected at other NMP sites.
- If the formaldehyde concentrations are grouped by average compass direction, the direction with the most concentrations is northwest, followed by southeast. If the formaldehyde concentrations are averaged by compass direction, the highest average concentrations are calculated for west and northeast. However, the westerly direction only includes two concentrations while the northeasterly direction includes only one.

Other wind directions, such as northwest, incorporate many concentrations of varying magnitude.

- The wind data for many of the sample days reflect a lake breeze/valley breeze system, one in which the wind direction in the morning is different from the afternoon/evening, switching directions with regularity due to daytime heating and geographic features such as the Great Salt Lake and the mountains on either side of the Salt Lake Valley (NHMU, 2015).

26.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 26-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 26-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 26-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for BTUT, as presented in Table 26-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 26-7. Table 26-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 26.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 26-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Utah Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Bountiful, Utah (Davis County) - BTUT					
Benzene	120.37	Benzene	9.39E-04	Formaldehyde	104.64
Formaldehyde	68.30	Formaldehyde	8.88E-04	Acetaldehyde	9.21
Ethylbenzene	67.10	Hexavalent Chromium	6.26E-04	Benzene	7.31
Dichloromethane	46.51	1,3-Butadiene	4.62E-04	Arsenic	4.26
Acetaldehyde	41.70	Naphthalene	2.84E-04	Dichloromethane	3.60
1,3-Butadiene	15.40	POM, Group 2b	1.79E-04	Carbon Tetrachloride	3.36
Naphthalene	8.35	Ethylbenzene	1.68E-04	1,2-Dichloroethane	2.84
Tetrachloroethylene	6.26	POM, Group 2d	1.23E-04	1,3-Butadiene	2.76
POM, Group 2b	2.03	POM, Group 5a	9.95E-05	Naphthalene	1.89
POM, Group 2d	1.39	Acetaldehyde	9.17E-05	Ethylbenzene	1.23

Table 26-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Utah Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Bountiful, Utah (Davis County) - BTUT					
Toluene	539.04	Acrolein	192,602.57	Formaldehyde	0.82
Hexane	370.73	1,3-Butadiene	7,700.14	Acetaldehyde	0.46
Xylenes	286.60	Formaldehyde	6,969.87	Dichloromethane	0.38
Methanol	205.85	Acetaldehyde	4,633.66	Propionaldehyde	0.11
Ethylene glycol	121.88	Benzene	4,012.18	Arsenic	0.07
Benzene	120.37	Xylenes	2,865.98	1,3-Butadiene	0.05
Formaldehyde	68.30	Naphthalene	2,782.33	Benzene	0.03
Ethylbenzene	67.10	Lead, PM	982.29	Naphthalene	0.02
Methyl isobutyl ketone	51.39	Arsenic, PM	703.33	Nickel	0.02
Dichloromethane	46.51	Hexane	529.62	Carbon Tetrachloride	0.01

Observations from Table 26-7 include the following:

- Benzene, formaldehyde, ethylbenzene, and dichloromethane are the highest emitted pollutants with cancer UREs in Davis County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are benzene, formaldehyde, hexavalent chromium, and 1,3-butadiene.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions in Davis County.
- Formaldehyde, which has the highest cancer risk approximation for BTUT, ranks second for both emissions-based lists behind benzene. Acetaldehyde, 1,3-butadiene, naphthalene, and ethylbenzene also appear on all three lists in Table 26-7. Dichloromethane, which has the highest annual average concentration and the fifth highest cancer risk approximation for BTUT, ranks fourth for emissions in Davis County but is not among those with the highest toxicity-weighted emissions (it ranks 22nd). Arsenic, carbon tetrachloride, and 1,2-dichloroethane, pollutants that have some of the highest cancer risk approximations for BTUT, appear on neither emissions-based list.
- POM, Group 2b is the ninth highest emitted “pollutant” in Davis County and ranks sixth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at BTUT including acenaphthylene, fluoranthene, and perylene. None of the PAHs included in POM, Group 2b were identified as pollutants of interest for BTUT.
- POM, Group 2d is the 10th highest emitted “pollutant” in Davis County and ranks eighth for toxicity-weighted emissions. POM, Group 2d also includes several PAHs sampled for at BTUT including phenanthrene, anthracene, and pyrene. None of the PAHs included in POM, Group 2d were identified as pollutants of interest for BTUT.

Observations from Table 26-8 include the following:

- Toluene, hexane, and xylenes are the highest emitted pollutants with noncancer RfCs in Davis County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, 1,3-butadiene, and formaldehyde. Although acrolein was sampled for at BTUT, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.
- Four of the highest emitted pollutants also have the highest toxicity-weighted emissions in Davis County.
- Formaldehyde, acetaldehyde, and dichloromethane have the highest noncancer hazard approximations for BTUT (although all are less than 1.0). Formaldehyde and benzene

are the only listed pollutants of interest to appear on both emissions-based lists. Acetaldehyde, arsenic, 1,3-butadiene, and naphthalene rank among the pollutants with the highest toxicity-weighted emissions but do not appear among those with the highest total emissions. Dichloromethane ranks 10th for its quantity emitted in Davis County but does not appear among those highest toxicity-weighted emissions. Propionaldehyde, nickel, and carbon tetrachloride do not appear on either emissions-based list in Table 26-8.

26.6 Summary of the 2013 Monitoring Data for BTUT

Results from several of the data treatments described in this section include the following:

- ❖ *Twenty-one pollutants failed at least one screen for BTUT.*
- ❖ *Dichloromethane had the highest annual average concentration among the pollutants of interest for BTUT, followed by formaldehyde and acetaldehyde.*
- ❖ *For the third year in a row, BTUT has the highest annual average formaldehyde concentration among NMP sites sampling this pollutant. BTUT also has the highest annual average concentration of acetaldehyde and second highest annual average concentration of arsenic among other NMP sites.*
- ❖ *Concentrations of benzene have an overall decreasing trend at BTUT; the 1-year average concentration for 2013 is the lowest 1-year average concentration of benzene calculated since the onset of sampling at BTUT. Concentrations of three carbonyl compounds increased significantly for 2013. The detection rate of 1,2-dichloroethane has been increasing steadily at BTUT over the last few years of sampling, although this leveled out for 2013.*
- ❖ *Formaldehyde has the highest cancer risk approximation among the pollutants of interest for BTUT and across the program. This is the only site-specific pollutant of interest with a cancer risk approximation greater than 100 in-a-million. None of the pollutants of interest have noncancer hazard approximations greater than an HQ of 1.0.*

27.0 Sites in Vermont

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP and NATTS sites in Vermont, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

27.1 Site Characterization

This section characterizes the Vermont monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The Vermont NATTS site (UNVT) and one of the UATMP sites (BURVT) are located in northwest Vermont in the Burlington-South Burlington, VT CBSA. The second UATMP site (RUVT) is located farther south in Rutland, Vermont. Figures 27-1 and 27-2 are the composite satellite images retrieved from ArcGIS Explorer showing the Burlington monitoring sites and their immediate surroundings. Figure 27-3 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 27-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile boundaries are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Figures 27-4 and 27-5 are the composite satellite image and emissions sources map for the Rutland site. Table 27-1 provides supplemental geographical information such as land use, location setting, and locational coordinates for each site.

Figure 27-1. Burlington, Vermont (BURVT) Monitoring Site

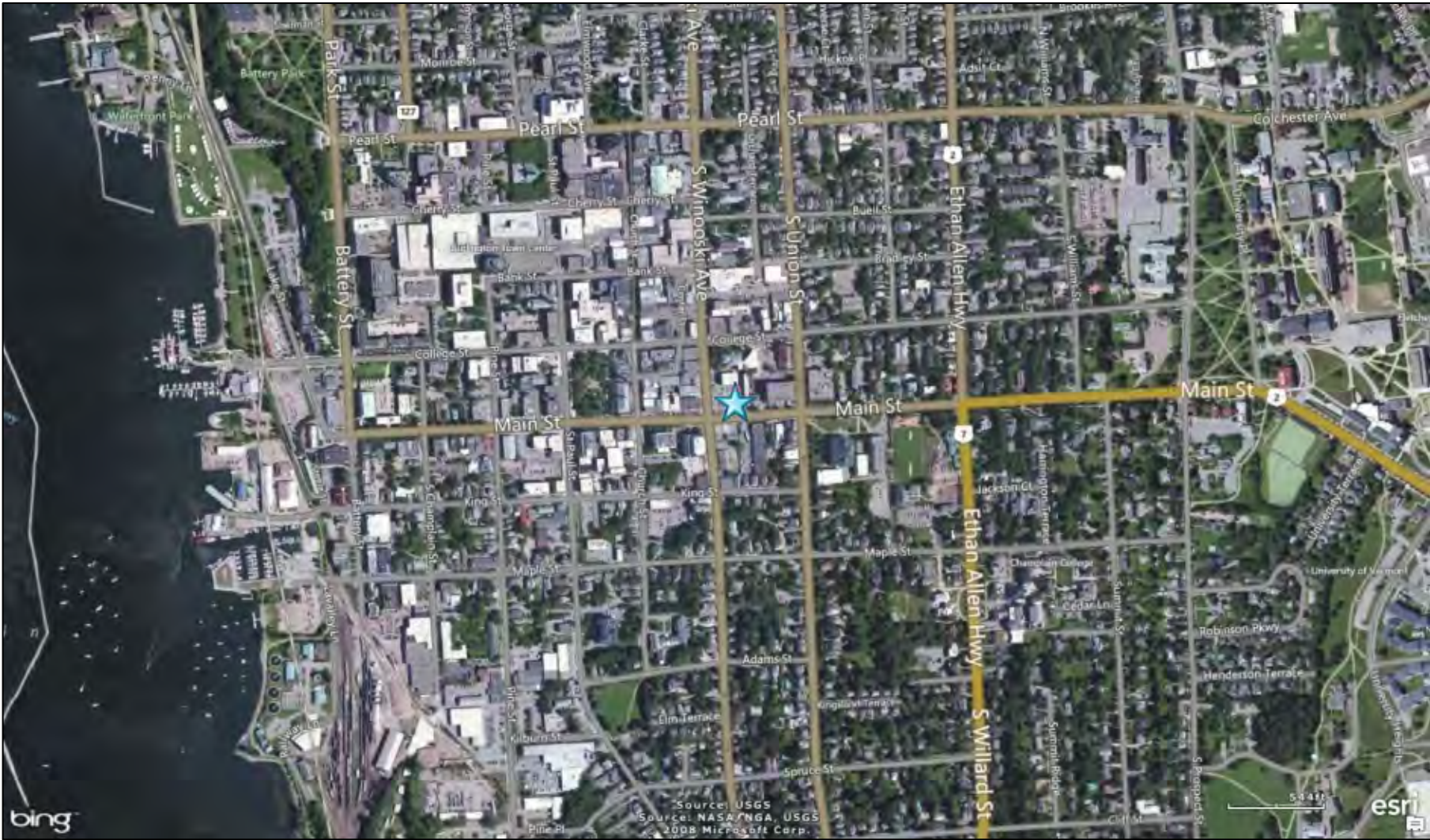


Figure 27-2. Underhill, Vermont (UNVT) Monitoring Site

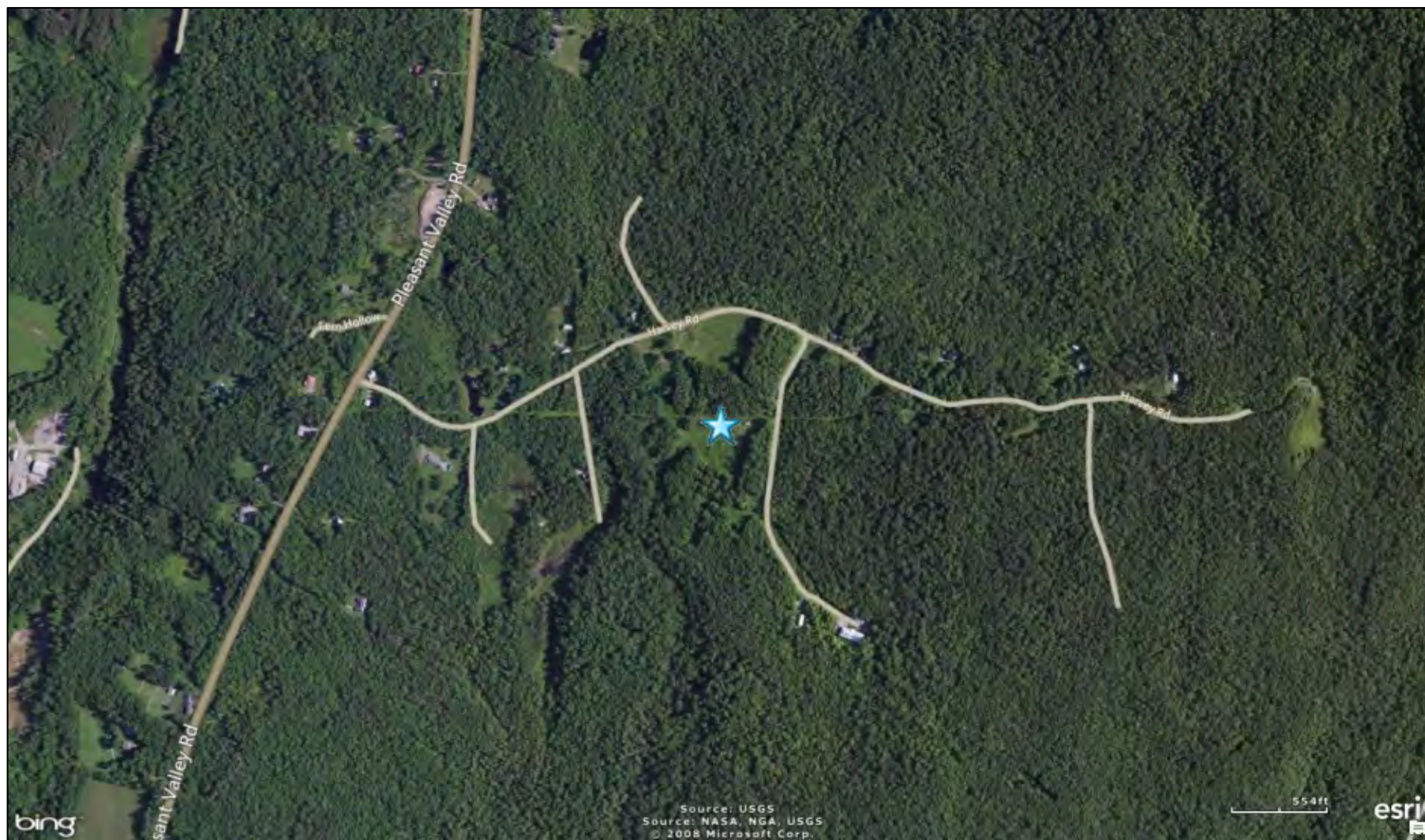


Figure 27-3. NEI Point Sources Located Within 10 Miles of BURVT and UNVT

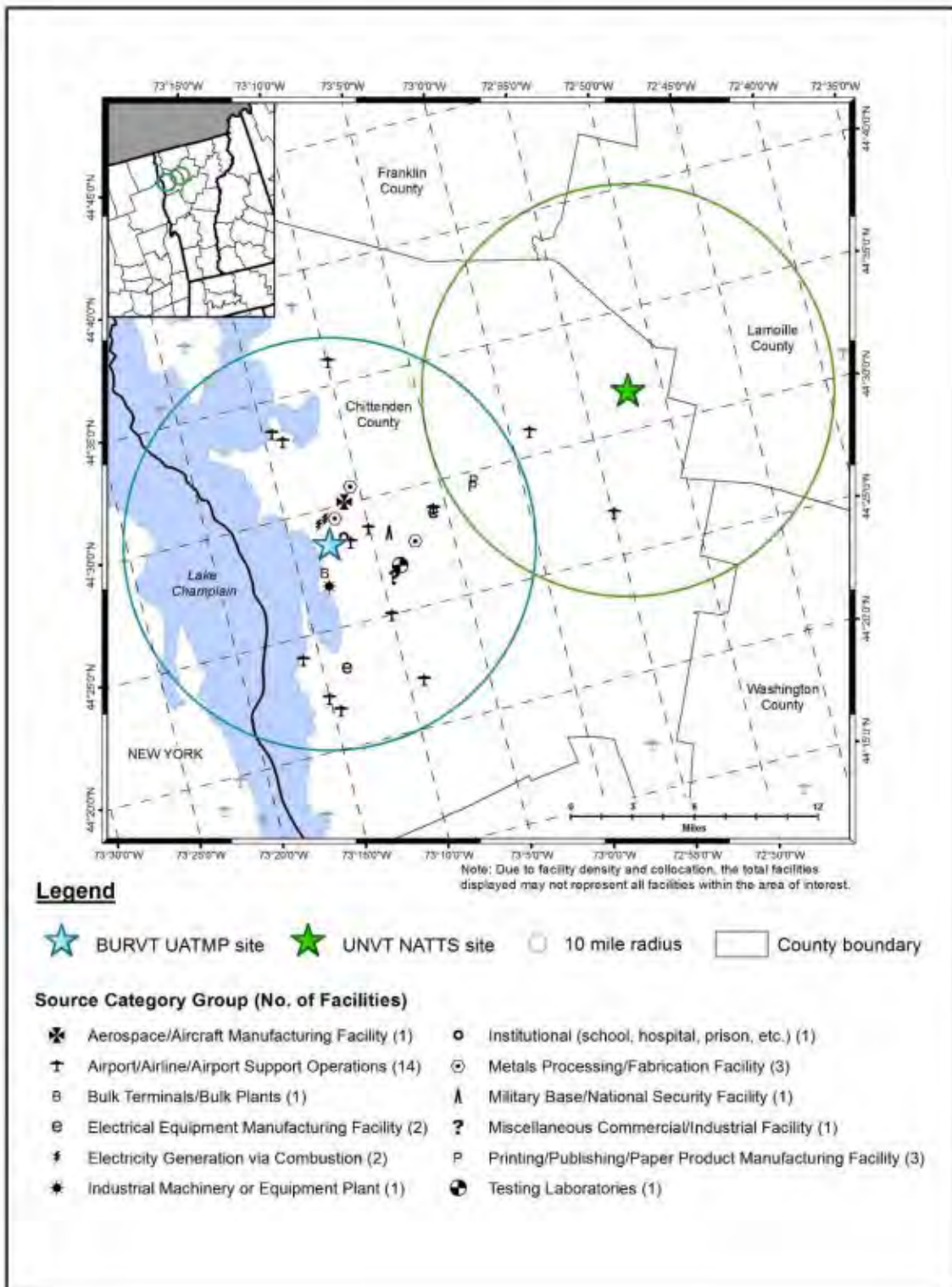


Figure 27-4. Rutland, Vermont (RUVT) Monitoring Site

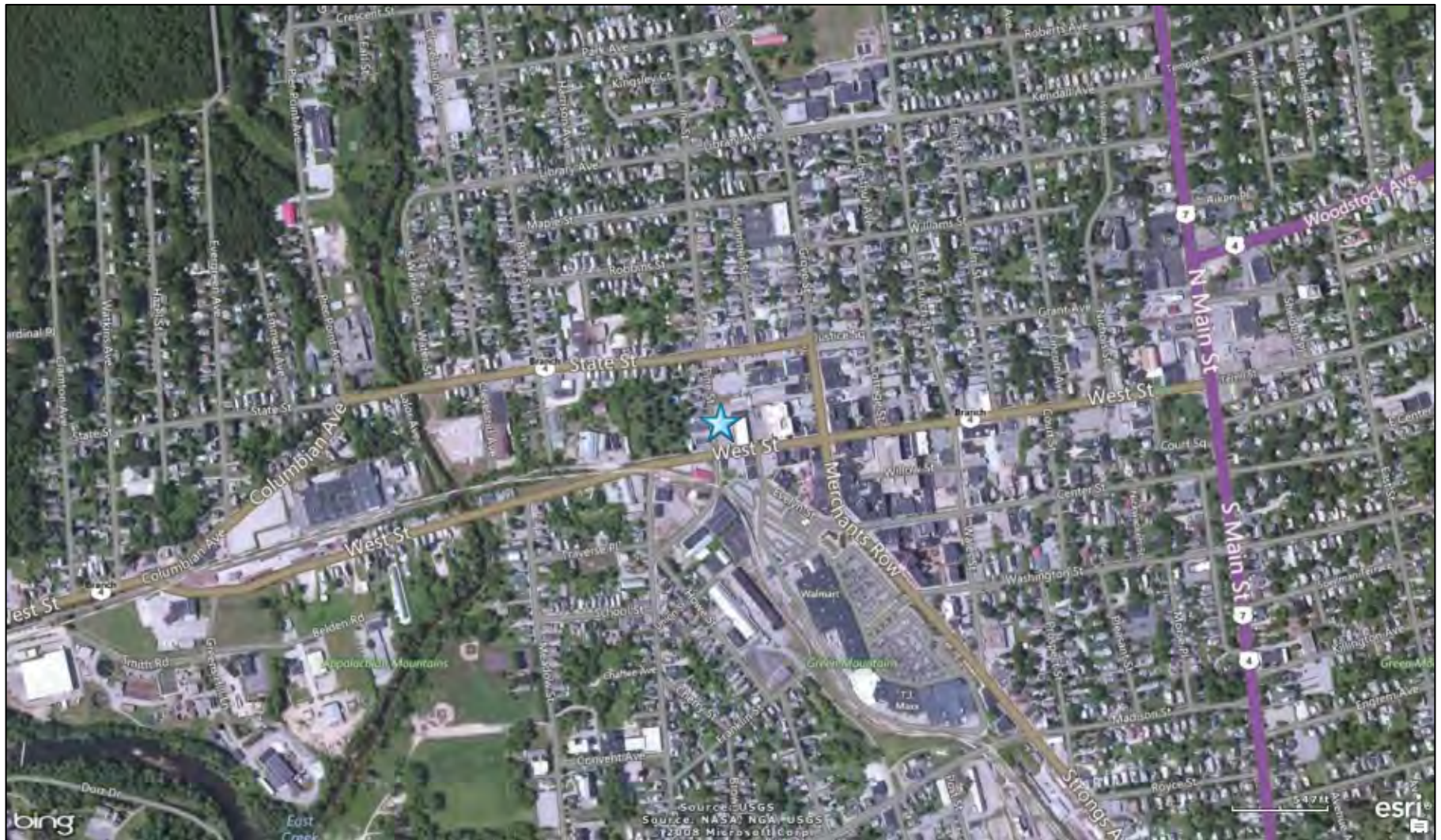


Figure 27-5. NEI Point Sources Located Within 10 Miles of RUVT

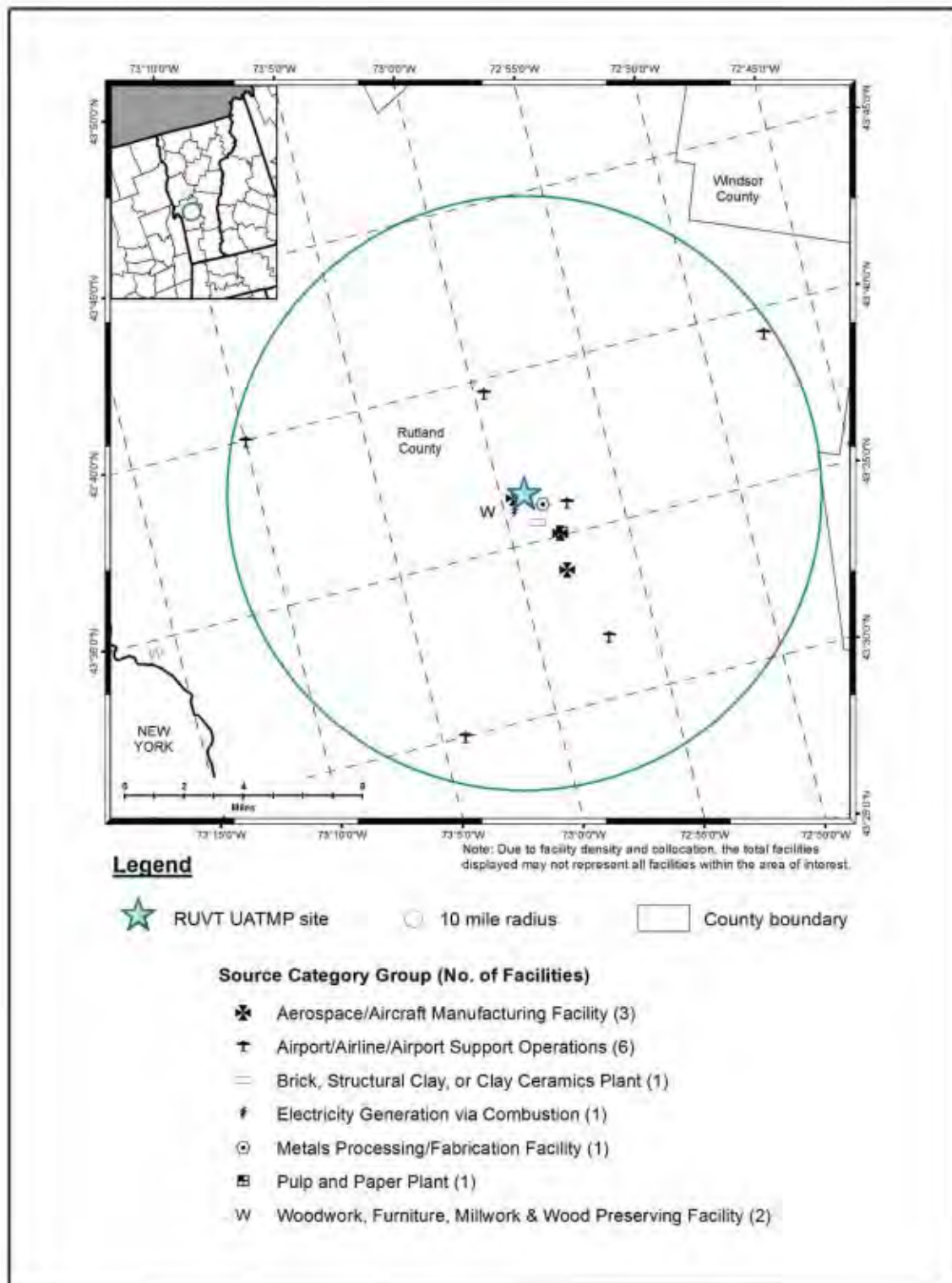


Table 27-1. Geographical Information for the Vermont Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
BURVT	50-007-0014	Burlington	Chittenden	Burlington-South Burlington, VT	44.4762, -73.2106	Commercial	Urban/City Center	CO, NO, NO ₂ , NO _x , Meteorological parameters, PM ₁₀ , PM _{2.5} , PM Coarse, PM _{2.5} Speciation.
<i>UNVT</i>	50-007-0007	Underhill	Chittenden	Burlington-South Burlington, VT	44.52839, -72.86884	Forest	Rural	Haze, Sulfate TSP, CO, SO ₂ , NO, NO _y , O ₃ , Meteorological parameters, PM ₁₀ , PM Coarse, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
RUVT	50-021-0002	Rutland	Rutland	Rutland, VT	43.608056, -72.982778	Commercial	Urban/City Center	CO, SO ₂ , NO, NO ₂ , NO _x , Meteorological parameters, PM ₁₀ , PM _{2.5} , PM Coarse, PM _{2.5} Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.
BOLD ITALICS = EPA-designated NATTS Site

BURVT is located in a municipal parking lot in downtown Burlington near the intersection of Main Street and South Winooski Avenue. This location is about one-half mile east of Burlington Bay on Lake Champlain. The areas to the west of the site are primarily commercial while the areas to the east are primarily residential, as shown in Figure 27-1. Route 2 (Main Street) and Route 7 (South Willard Street) intersect two blocks east of the monitoring site and I-89 runs north-south just over 1 mile east of the site. Between the two roadways and the interstate lies the University of Vermont.

The UNVT monitoring site is located on the Proctor Maple Research Center in Underhill, Vermont, which is east of the Burlington area. This research station is part of the University of Vermont, with research focused on the sugar maple tree and sap collection methods (UVM, 2015). Figure 27-2 shows that the area surrounding the site is rural in nature and heavily forested. Mount Mansfield, the highest peak in Vermont, lies to the east in Underhill State Park, less than 3 miles away. This site is intended to serve as a background site for the region for trends assessment, standards compliance, and long-range transport assessment.

UNVT and BURVT are located approximately 16 miles apart, as shown in Figure 27-3. Most of the emissions sources are located between these two sites, although closer to BURVT. The source category with the greatest number of emissions sources surrounding these sites is the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. The sources closest to BURVT are a medical school/hospital, two heliports at the medical school, two facilities generating electricity via combustion, and a metals processing/fabrication facility. The sources closest to UNVT are private airports.

The RUVT monitoring site is located in Rutland, in central Vermont. The city of Rutland is in a valley between the Green Mountains to the east and Taconic Mountains to the west. The monitoring site is located in the courthouse parking lot in downtown Rutland, just north of West Street. Commercial areas are located to the east and south, while residential areas are located to the north and west, as shown in Figure 27-4. A railway parallels Route 4 coming into Rutland from the west, crosses under Route 4, then meanders around a shopping plaza just south of Route 4. The intersection of Route 4-Business (West Street) and Route 7 is approximately one-half mile east of the site. Figure 27-5 shows that most of the emissions sources within

10 miles of RUVT are located along Route 7 (Main Street), just south of the monitoring site or along West Street to the west of the site. The source categories with the greatest number of sources within 10 miles of the site include airport operations (6) and aerospace/aircraft manufacturing (3). The source closest to RUVT is an aerospace/aircraft manufacturer.

Table 27-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Vermont monitoring sites. Table 27-2 includes both county-level population and vehicle registration information. Table 27-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 27-2 presents the county-level daily VMT for Chittenden and Rutland Counties.

Table 27-2. Population, Motor Vehicle, and Traffic Information for the Vermont Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
BURVT	Chittenden	159,515	172,203	14,200	Main St, South of Willard St	4,051,781
<i>UNVT</i>				1,100	Pleasant Valley Rd, North of Harvey Rd	
RUVT	Rutland	60,622	79,795	10,400	Bus US-4 (West St) between Pine St and Evelyn St	1,736,164

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect 2013 data (VT DMV, 2014)

³AADT reflects 2009 data for BURVT and 2011 data for UNVT (CCRPC, 2014) and 2013 data for RUVT (VTrans, 2014a)

⁴County-level VMT reflects 2013 data (Vtrans, 2014b)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 27-2 include the following:

- The population for Chittenden County is more than twice the population for Rutland County. The populations for both counties are in the bottom third compared to other counties with NMP sites.
- A similar pattern is shown for the rankings of the vehicle ownership data for both counties, although the number of vehicles registered in each county is higher than the population counts.
- The traffic volume is highest near BURVT and lowest near UNVT among the Vermont sites. The traffic estimate near BURVT is in the middle of the range compared to other NMP sites while the traffic volumes for RUVT and UNVT are in the bottom third compared to other NMP sites. The traffic estimate for BURVT is provided for Main Street south of Willard Street; for UNVT, the data is for Pleasant

Valley Road, north of Harvey Road; and for RUVT, the data is for US-4 Business between Pine Street and Evelyn Street.

- The county-level daily VMT for Chittenden County is more than twice the VMT for Rutland County, with both VMTs in the bottom third compared to other counties with NMP sites.

27.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Vermont on sample days, as well as over the course of the year.

27.2.1 Climate Summary

The city of Burlington is located just to the east of Lake Champlain in northwest Vermont. Lake Champlain has a moderating effect on the city's temperatures, keeping the city slightly warmer in winter than it would be given its New England location. The town of Underhill is located to the east of Burlington but still within the Burlington metro area. The city of Rutland is located 60 miles south of the Burlington area. Rutland is within the same climatic division of Vermont as Burlington, but misses the moderating influences of Lake Champlain. The state of Vermont is affected by many storm systems that track across the country, producing variable weather and often cloudy skies. Summers in Vermont are pleasant, with warm days and cool nights, escaping much of the heat and humidity most of the East Coast experiences. Winters are warmer in the Champlain Valley region than in other portions of the state but snow is common state-wide. The highest precipitation amounts are generally received during the summer months while greater than 15 inches of snow can be expected each month during the winter. Average annual winds flow parallel to the valleys, generally from the south ahead of advancing weather systems, or from the north behind these systems. These storm systems tend to be moderated somewhat due to the Adirondacks to the west and Green Mountains to the east (Wood, 2004; NCDC, 2015; NOAA, 2015c).

27.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the Vermont monitoring sites (NCDC, 2013), as described in Section 3.4.2. The closest weather station to BURVT is located at Burlington International Airport; nearest RUVT is Rutland State Airport; and nearest UNVT is Morrisville-Stowe State Airport (WBANs 14742,

94737, and 54771, respectively). Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 27-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 27-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 27-3 is the 95 percent confidence interval for each parameter. Note that the number of sample days included in the sample day average for UNVT is twice the number of sample days for BURVT and RUVT. This is because sampling at UNVT occurred on a 1-in-6 day schedule, while sampling at BURVT and RUVT occurred on a 1-in-12 day schedule.

As shown in Table 27-3, meteorological conditions on sample days were representative of weather conditions experienced throughout the year near these sites. The averages were most similar for UNVT, where 1 degree or less (or millibar, knot, or percentage) separates the sample day averages from the full-year averages. The sample day vs. full-year averages for RUVT exhibit the most variability, although the largest difference was calculated for BURVT's relative humidity.

Compared to other NMP sites, the Vermont sites experience some of the coldest temperatures. UNVT and RUVT rank fifth and sixth, respectively for the lowest average maximum temperature and rank fourth and sixth, respectively, for the lowest average temperatures. UNVT also has the second lowest average wind speed (behind CELA).

Table 27-3. Average Meteorological Conditions near the Vermont Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Burlington, Vermont - BURVT									
Burlington Intl. Airport 14742 (44.47, -73.15)	3.1 miles	Sample Days (31)	56.1 ± 8.0	48.4 ± 7.3	36.2 ± 7.4	42.9 ± 6.8	65.3 ± 4.2	1015.9 ± 2.7	7.0 ± 1.2
	100° (E)	2013	55.6 ± 2.2	47.3 ± 2.1	36.0 ± 2.1	42.5 ± 1.9	67.4 ± 1.3	1016.5 ± 0.8	6.2 ± 0.3
Rutland, Vermont - RUVT									
Rutland State Airport 94737 (43.53, -72.95)	5.4 miles	Sample Days (31)	55.6 ± 7.1	47.2 ± 6.6	36.3 ± 6.9	42.2 ± 6.3	68.3 ± 3.9	NA	6.5 ± 0.8
	162° (SSE)	2013	53.7 ± 2.1	45.3 ± 1.9	35.0 ± 2.1	41.0 ± 1.8	70.1 ± 1.3	NA	6.0 ± 0.3
Underhill, Vermont - UNVT									
Morrisville-Stowe State Airport 54771 (44.53, -72.61)	12.6 miles	Sample Days (64)	54.5 ± 5.6	44.8 ± 5.1	34.9 ± 5.1	40.4 ± 4.8	71.5 ± 2.8	1017.0 ± 1.7	3.2 ± 0.6
	88° (E)	2013	53.5 ± 2.2	44.0 ± 2.0	35.4 ± 2.1	40.0 ± 1.9	72.2 ± 1.1	1017.1 ± 0.8	3.0 ± 0.2

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA = Sea level pressure was not recorded at the Rutland State Airport.

27.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations at Burlington International Airport (for BURVT), Rutland State Airport (for RUVT), and Morrisville-Stowe State Airport (for UNVT) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

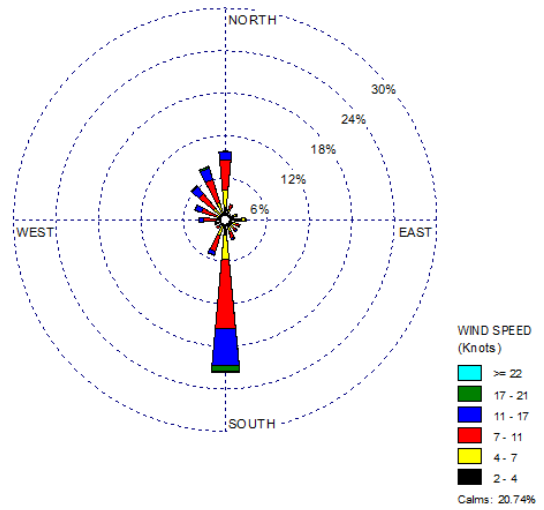
Figure 27-6 presents a map showing the distance between the weather station and BURVT, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 27-6 also presents three different wind roses for the BURVT monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction in 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 27-7 and 27-8 present the three wind roses and distance maps for the RUVT and UNVT monitoring sites, respectively.

Figure 27-6. Wind Roses for the Burlington International Airport Weather Station near BURVT

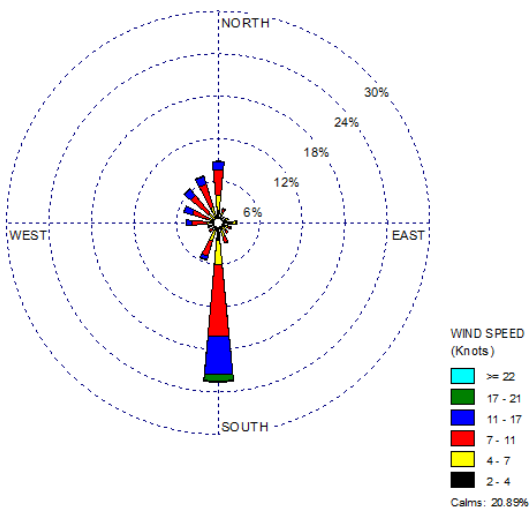
Location of BURVT and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

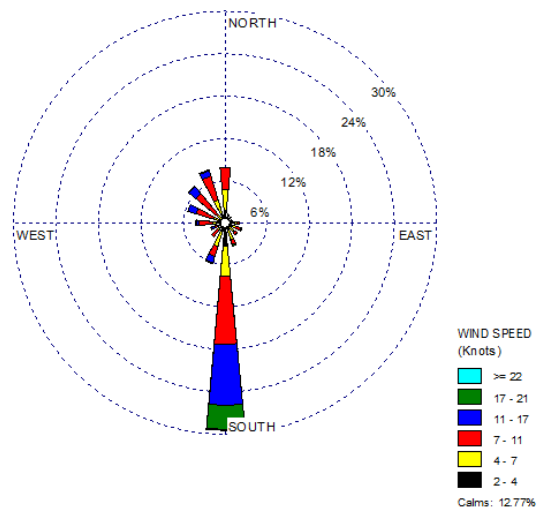
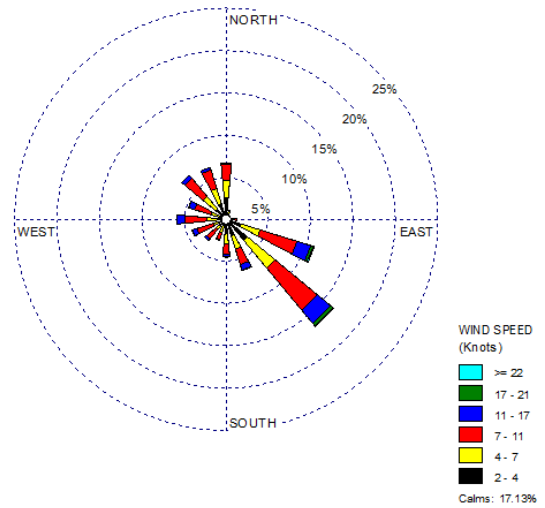


Figure 27-7. Wind Roses for the Rutland State Airport Weather Station near RUVT

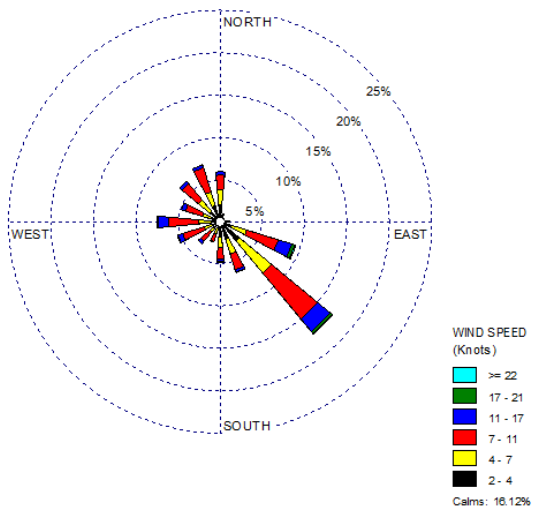
Location of RUVT and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

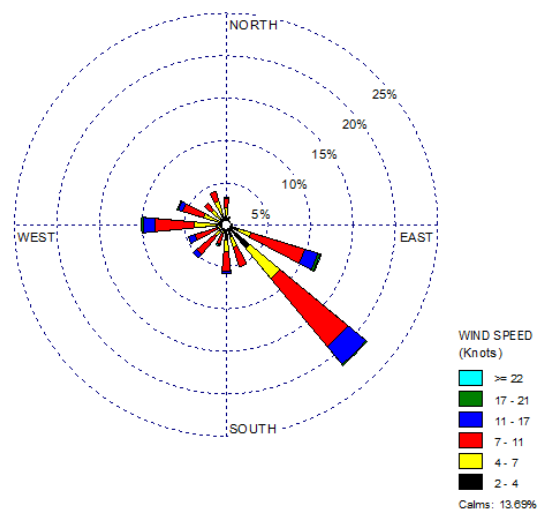
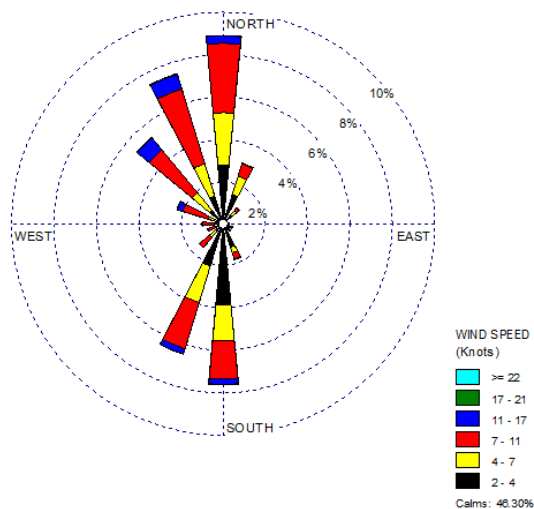


Figure 27-8. Wind Roses for the Morrisville-Stowe State Airport Weather Station near UNVT

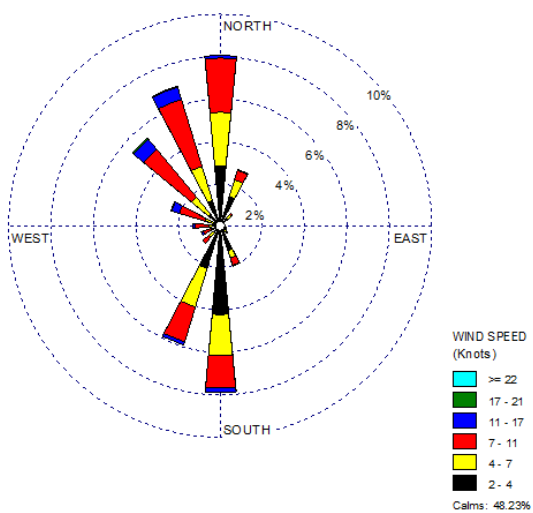
Location of UNVT and Weather Station



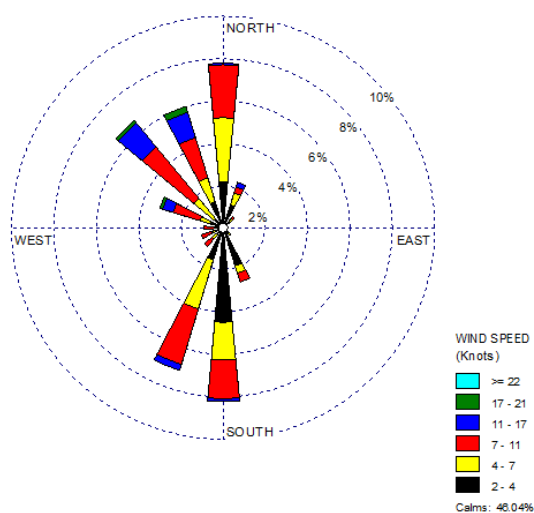
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 27-6 for BURVT include the following:

- The Burlington International Airport weather station is located approximately 3 miles east of BURVT, which is four times farther away from Lake Champlain than the monitoring site.
- The historical wind rose shows that southerly winds are prevalent near BURVT, accounting for nearly 22 percent of the hourly measurements. Calm winds (those less than or equal to 2 knots) account for another 21 percent of measurements. Winds from the northwest quadrant were also commonly observed while winds from the eastern quadrants were rarely observed.
- The wind patterns shown on the 2013 wind rose are similar to the historical wind patterns, indicating that wind conditions observed during 2013 were similar to those observed over the previous 10 years.
- The sample day wind rose shows that southerly winds prevailed on sample days, but account for a higher percentage of observations (nearly 30 percent). The increase in southerly winds coincides with a decrease in calm winds (down to 13 percent on sample days). Winds from the north-northwest and north were observed equally on sample days, which is another difference between the sample day and full-year wind rose.

Observations from Figure 27-7 for RUVT include the following:

- The Rutland State Airport weather station is located 5.4 miles south-southeast of RUVT.
- The historical wind rose shows that east-southeasterly and southeasterly winds were prevalent near RUVT, as these directions account for more than one-quarter of the hourly measurements. Winds from the northwest quadrant, and to a less extent, the southwest quadrant were also commonly observed while winds from the northeast quadrant were generally not observed. Calm winds were observed for 17 percent of the hourly measurements.
- The wind patterns shown on the 2013 wind rose are similar to the historical wind patterns, although a slightly higher percentage of winds from the southeast and slightly fewer east-southeasterly winds were observed in 2013.
- The sample day wind rose exhibits similar wind patterns as the historical and full-year wind roses, but with higher percentages of east-southeasterly and southeasterly winds (together accounting for more than one-third of wind observations). This corresponds with fewer calm observations (less than 14 percent). Westerly winds were also observed more often on sample days while northwesterly to northerly winds were observed less frequently.

Observations from Figure 27-8 for UNVT include the following:

- The Morrisville-Stowe Airport weather station is located less than 13 miles east of UNVT. Between the site and the weather station lie the Green Mountains.
- The historical wind rose shows that calm winds were prevalent near UNVT, as calm winds were observed for 46 percent of the hourly measurements. Winds from the northwest to north account for approximately 21 percent of the wind observations greater than 2 knots. Winds from the south to south-southwest account for another roughly 14 percent of observations.
- The wind patterns shown on the 2013 wind rose are similar to the historical wind patterns.
- The sample day wind rose shows that wind conditions on sample days were similar to those experienced throughout 2013, although number of observations from the north-northwest is slightly less while the number of observations from the northwest is slightly higher. A higher percentage of stronger winds from these directions was also observed on sample days.

27.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Vermont monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 27-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 27-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. VOCs were sampled for year-round at BURVT and RUVT, while hexavalent chromium, PAHs, and metals (PM₁₀) were sampled for in addition to VOCs at UNVT. Hexavalent chromium sampling at UNVT, however, was discontinued at the end of June.

Table 27-4. Risk-Based Screening Results for the Vermont Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Burlington, Vermont - BURVT						
Benzene	0.13	31	31	100.00	23.13	23.13
Carbon Tetrachloride	0.17	31	31	100.00	23.13	46.27
1,3-Butadiene	0.03	30	30	100.00	22.39	68.66
1,2-Dichloroethane	0.038	30	30	100.00	22.39	91.04
<i>p</i> -Dichlorobenzene	0.091	5	27	18.52	3.73	94.78
Hexachloro-1,3-butadiene	0.045	4	4	100.00	2.99	97.76
Ethylbenzene	0.4	2	31	6.45	1.49	99.25
Trichloroethylene	0.2	1	4	25.00	0.75	100.00
Total		134	188	71.28		
Rutland, Vermont - RUVT						
Benzene	0.13	31	31	100.00	24.60	24.60
Carbon Tetrachloride	0.17	31	31	100.00	24.60	49.21
1,3-Butadiene	0.03	29	29	100.00	23.02	72.22
1,2-Dichloroethane	0.038	27	27	100.00	21.43	93.65
Ethylbenzene	0.4	5	31	16.13	3.97	97.62
Hexachloro-1,3-butadiene	0.045	3	4	75.00	2.38	100.00
Total		126	153	82.35		
Underhill, Vermont - UNVT						
Benzene	0.13	59	60	98.33	26.11	26.11
Carbon Tetrachloride	0.17	58	60	96.67	25.66	51.77
1,2-Dichloroethane	0.038	53	53	100.00	23.45	75.22
Arsenic (PM ₁₀)	0.00023	38	56	67.86	16.81	92.04
1,3-Butadiene	0.03	7	11	63.64	3.10	95.13
Hexachloro-1,3-butadiene	0.045	5	5	100.00	2.21	97.35
Naphthalene	0.029	4	59	6.78	1.77	99.12
Nickel (PM ₁₀)	0.0021	1	60	1.67	0.44	99.56
Trichloroethylene	0.2	1	2	50.00	0.44	100.00
Total		226	366	61.75		

Observations from Table 27-4 include the following:

- Eight pollutants failed at least one screen for BURVT; 71 percent of concentrations for these eight pollutants were greater than their associated risk screening value (or failed screens).
- Six pollutants contributed to 95 percent of failed screens for BURVT and therefore were identified as pollutants of interest for this site.

- Six pollutants failed at least one screen for RUVT; 82 percent of concentrations for these six pollutants were greater than their associated risk screening value (or failed screens).
- Five pollutants contributed to 95 percent of failed screens for RUVT and therefore were identified as pollutants of interest for this site.
- Nine pollutants failed at least one screen for UNVT; 62 percent of concentrations for these nine pollutants were greater than their associated risk screening value (or failed screens).
- Five pollutants contributed to 95 percent of failed screens for UNVT and therefore were identified as pollutants of interest for this site. These five include four VOCs and one PM₁₀ metal.
- The Vermont sites have four pollutants of interest in common: benzene, carbon tetrachloride, 1,3-butadiene, and 1,2-dichloroethane.

27.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Vermont monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at BURVT, RUVT, and UNVT are provided in Appendices J, M, N, and O.

27.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Vermont site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a

given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Vermont monitoring sites are presented in Table 27-5, where applicable. Note that concentrations of arsenic for UNVT are presented in ng/m³ for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 27-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Vermont Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m ³)	2nd Quarter Average (µg/m ³)	3rd Quarter Average (µg/m ³)	4th Quarter Average (µg/m ³)	Annual Average (µg/m ³)
Burlington, Vermont - BURVT						
Benzene	31/31	0.85 ± 0.09	0.54 ± 0.09	0.62 ± 0.16	0.58 ± 0.09	0.65 ± 0.06
1,3-Butadiene	30/31	0.08 ± 0.01	0.06 ± 0.03	0.08 ± 0.03	0.07 ± 0.03	0.07 ± 0.01
Carbon Tetrachloride	31/31	0.65 ± 0.05	0.62 ± 0.07	0.67 ± 0.06	0.54 ± 0.08	0.62 ± 0.03
<i>p</i> -Dichlorobenzene	27/31	0.07 ± 0.02	0.06 ± 0.02	0.07 ± 0.02	0.04 ± 0.02	0.06 ± 0.01
1,2-Dichloroethane	30/31	0.09 ± 0.03	0.10 ± 0.02	0.07 ± 0.01	0.07 ± 0.01	0.08 ± 0.01
Hexachloro-1,3-butadiene	4/31	0.02 ± 0.03	0.01 ± 0.03	0	0.01 ± 0.03	0.01 ± 0.01
Rutland, Vermont - RUVT						
Benzene	31/31	1.26 ± 0.49	0.64 ± 0.19	0.49 ± 0.10	0.81 ± 0.34	0.81 ± 0.18
1,3-Butadiene	29/31	0.17 ± 0.09	0.08 ± 0.04	0.06 ± 0.02	0.13 ± 0.07	0.11 ± 0.03
Carbon Tetrachloride	31/31	0.65 ± 0.08	0.66 ± 0.06	0.66 ± 0.09	0.59 ± 0.03	0.63 ± 0.03
1,2-Dichloroethane	27/31	0.10 ± 0.02	0.09 ± 0.02	0.08 ± 0.02	0.04 ± 0.03	0.08 ± 0.01
Ethylbenzene	31/31	0.29 ± 0.10	0.31 ± 0.09	0.31 ± 0.13	0.20 ± 0.11	0.27 ± 0.05

^a Average concentrations provided for the pollutant below the blue line are presented in ng/m³ for ease of viewing.

Table 27-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Vermont Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Underhill, Vermont - UNVT						
Benzene	60/60	0.74 ± 0.45	0.23 ± 0.06	0.22 ± 0.02	0.29 ± 0.07	0.37 ± 0.12
1,3-Butadiene	11/60	0	<0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 $\pm <0.01$
Carbon Tetrachloride	60/60	0.59 ± 0.06	0.69 ± 0.04	0.67 ± 0.03	0.56 ± 0.09	0.63 ± 0.03
1,2-Dichloroethane	53/60	0.08 ± 0.01	0.10 ± 0.01	0.05 ± 0.01	0.06 ± 0.02	0.07 ± 0.01
Arsenic (PM_{10}) ^a	56/60	0.18 ± 0.07	0.37 ± 0.08	0.29 ± 0.12	0.29 ± 0.08	0.28 ± 0.05

^a Average concentrations provided for the pollutant below the blue line are presented in ng/m^3 for ease of viewing.

Observations for BURVT from Table 27-5 include the following:

- BURVT sampled VOCs on a 1-in-12 day schedule, yielding half as many samples as UNVT.
- Benzene is the pollutant with the highest annual average concentration for BURVT, followed by carbon tetrachloride, although their annual averages are similar. All of the remaining annual average concentrations for the pollutants of interest for BURVT are less than $0.1 \mu\text{g}/\text{m}^3$.
- Concentrations of benzene measured at BURVT range from $0.35 \mu\text{g}/\text{m}^3$ to $1.02 \mu\text{g}/\text{m}^3$, which is the only benzene concentration greater than $1 \mu\text{g}/\text{m}^3$. Six of the eight concentrations greater than $0.8 \mu\text{g}/\text{m}^3$ were measured in either January or February, which explains why the first quarter average concentration is higher than the other quarterly averages. The difference, however, is not statistically significant. Similar observations were made in the 2011 and 2012 NMP reports.
- Concentrations of carbon tetrachloride and *p*-dichlorobenzene appear lowest during the fourth quarter of 2013. The two lowest carbon tetrachloride measurements were collected at BURVT in December. For *p*-dichlorobenzene, two of the four non-detects and the minimum measured detection were measured in December. However, the differences among the quarterly average concentrations are not statistically significant.
- Concentrations of 1,2-dichloroethane measured at BURVT appear higher during the first half of the year. Concentrations of 1,2-dichloroethane range from $0.04 \mu\text{g}/\text{m}^3$ to $0.16 \mu\text{g}/\text{m}^3$, plus a single non-detect. None of the 10 highest concentrations were measured after May.

- For each of the quarterly average concentrations of hexachloro-1,3-butadiene, the confidence interval is larger than the average itself, indicating a relatively high level of variability in the measurements. Hexachloro-1,3-butadiene was detected only four times at BURVT and was not detected at all during the third quarter, resulting in a third quarter average concentration of zero.

Observations for RUVT from Table 27-5 include the following:

- RUVT also sampled VOCs on a 1-in-12 day schedule.
- Benzene, carbon tetrachloride, and ethylbenzene have the highest annual average concentrations for RUVT, although none of the annual average concentrations are greater than $1 \mu\text{g}/\text{m}^3$.
- The quarterly average concentrations of benzene exhibit considerably variability, with the first quarter average concentration the highest and the third quarter average the lowest. Concentrations of benzene measured at RUVT range from $0.30 \mu\text{g}/\text{m}^3$ to $2.09 \mu\text{g}/\text{m}^3$. Of the seven benzene concentrations greater than $1 \mu\text{g}/\text{m}^3$ measured at RUVT, four were measured during the first quarter (including the maximum, although a similar concentration was also measured during the fourth quarter), one was measured during the second quarter, and two were measured during the fourth quarter. No benzene concentrations greater than $0.65 \mu\text{g}/\text{m}^3$ were measured during the third quarter of 2013.
- Concentrations of 1,3-butadiene measured at RUVT span an order of magnitude, ranging from $0.033 \mu\text{g}/\text{m}^3$ to $0.399 \mu\text{g}/\text{m}^3$, including two non-detects. Concentrations of 1,3-butadiene appear higher during the first and fourth quarters of 2013 and exhibit more variability. Nine of the 11 concentrations of 1,3-butadiene greater than $0.1 \mu\text{g}/\text{m}^3$ were measured at RUVT during the first or fourth quarters.
- Concentrations of carbon tetrachloride also appear lowest during the fourth quarter of 2013, although the difference for RUVT is less noticeable than the difference for BURVT.
- Similar to BURVT, concentrations of 1,2-dichloroethane measured at RUVT appear higher during the first half of the year. Concentrations of 1,2-dichloroethane range from $0.05 \mu\text{g}/\text{m}^3$ to $0.14 \mu\text{g}/\text{m}^3$, plus four non-detects. All of the concentrations greater than $0.1 \mu\text{g}/\text{m}^3$ were measured between January and July and all four non-detects were measured in October and November.
- Concentrations of ethylbenzene measured at RUVT also appear lowest during the fourth quarter of 2013. Concentrations of ethylbenzene measured at RUVT span an order of magnitude, ranging from $0.065 \mu\text{g}/\text{m}^3$ to $0.653 \mu\text{g}/\text{m}^3$, with both the maximum and minimum concentrations measured during the fourth quarter of 2013. However, no other ethylbenzene concentrations greater than the median concentration ($0.235 \mu\text{g}/\text{m}^3$) were measured during the fourth quarter.

Observations for UNVT from Table 27-5 include the following:

- Sampling at UNVT occurred on a 1-in-6 day schedule.
- All of the annual average concentrations for the pollutants of interest for UNVT are less than $1 \mu\text{g}/\text{m}^3$.
- Carbon tetrachloride has the highest annual average concentration for UNVT ($0.63 \pm 0.03 \mu\text{g}/\text{m}^3$). The annual average concentrations of this pollutant are similar across the three Vermont sites, differing by only $0.01 \mu\text{g}/\text{m}^3$.
- Benzene has the second highest annual average concentration of the pollutants of interest for UNVT ($0.38 \pm 0.04 \mu\text{g}/\text{m}^3$). However, this is the lowest annual average concentration among the Vermont sites as well as all NMP sites sampling benzene.
- Concentrations of benzene measured during the first quarter of 2013 are considerably higher than those measured during the rest of the year, based on the quarterly average concentrations shown in Table 27-5. Concentrations of benzene measured at UNVT range from $0.109 \mu\text{g}/\text{m}^3$ to $3.67 \mu\text{g}/\text{m}^3$. The maximum concentration was measured on February 21, 2013 and is more than twice the next highest concentration ($1.17 \mu\text{g}/\text{m}^3$), also measured in February. All other benzene concentrations measured at UNVT are less than $0.65 \mu\text{g}/\text{m}^3$. Of the 12 highest benzene measurements collected at UNVT, all but two were measured during the first quarter of 2013 and only one of the first quarter benzene concentrations is less than the median concentration for the year ($0.25 \mu\text{g}/\text{m}^3$).
- UNVT has the fewest measured detections of 1,3-butadiene (11) among NMP sites sampling VOCs with Method TO-15, none of which were measured prior to the end of June.
- Similar to BURVT and RUVT, concentrations of 1,2-dichloroethane measured at UNVT appear higher during the first half of the year. Concentrations of 1,2-dichloroethane range from $0.045 \mu\text{g}/\text{m}^3$ to $0.15 \mu\text{g}/\text{m}^3$, plus seven non-detects. All but one of the nine concentrations greater than $0.1 \mu\text{g}/\text{m}^3$ were measured between January and May and six of the seven non-detects were measured during the second half of the year.
- Arsenic was detected in most of the metals samples collected at UNVT. In addition to four non-detects, concentrations of arsenic range from $0.05 \text{ ng}/\text{m}^3$ to $0.80 \text{ ng}/\text{m}^3$. Among NMP sites sampling arsenic, UNVT has the lowest annual average concentration of this pollutant ($0.28 \pm 0.05 \text{ ng}/\text{m}^3$).

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Vermont monitoring sites from those tables include the following:

- BURVT appears twice in Table 4-9 for VOCs. BURVT has the sixth highest annual average concentration of *p*-dichlorobenzene and the 10th highest annual average concentration of 1,2-dichloroethane among NMP sites sampling VOCs.
- RUVT does not appear in Table 4-9 for VOCs.
- UNVT does not appear in Tables 4-9 through 4-12 and is often among the sites with lowest annual average concentrations for the program-level pollutants of interest.

27.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 27-4 for BURVT, RUVT, and UNVT. Figures 27-9 through 27-16 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.

Figure 27-9. Program vs. Site-Specific Average Arsenic (PM₁₀) Concentration

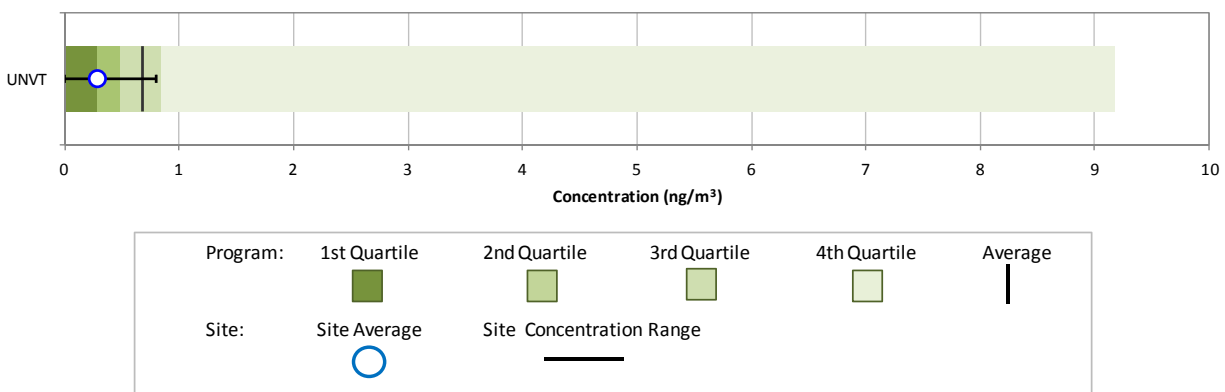


Figure 27-10. Program vs. Site-Specific Average Benzene Concentrations

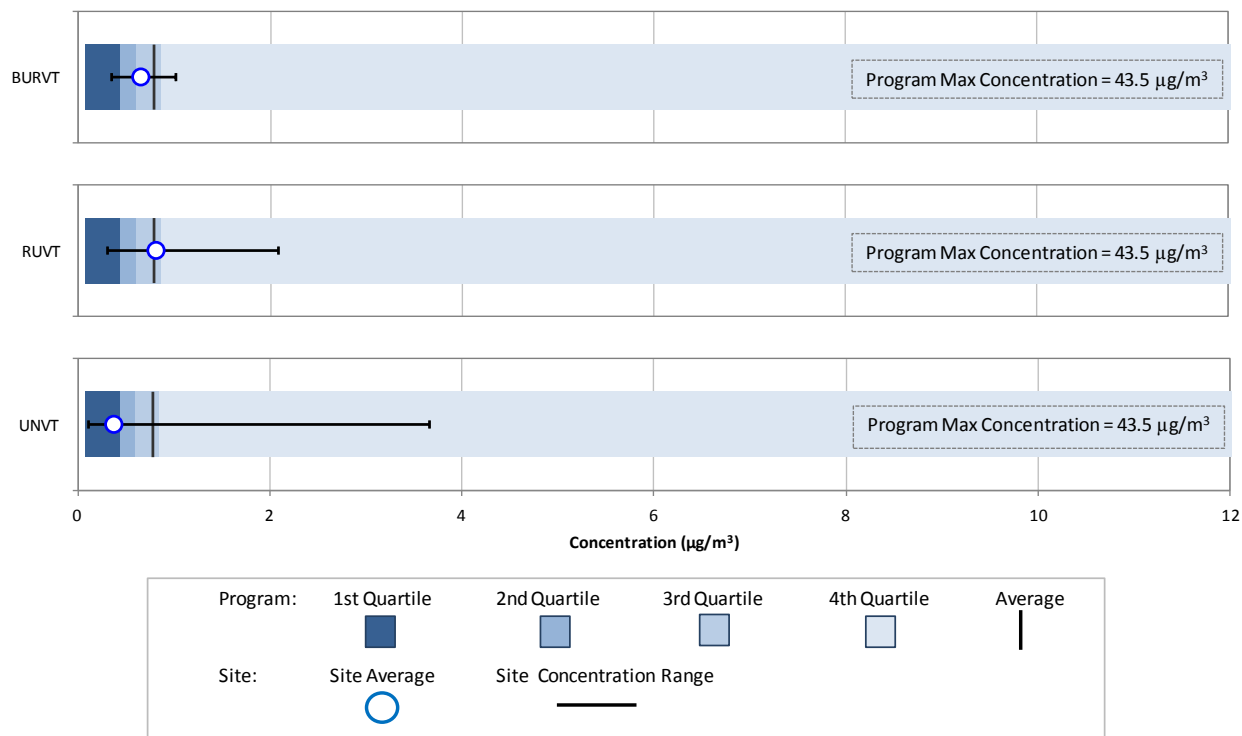


Figure 27-11. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

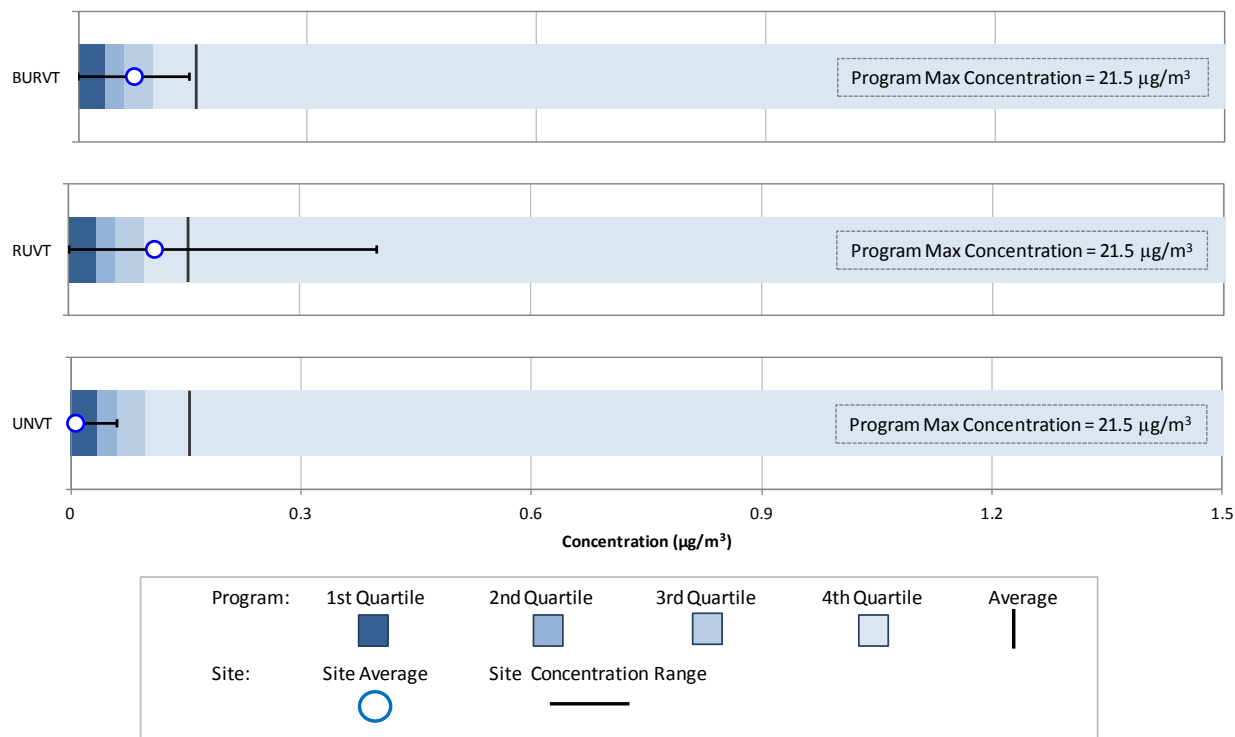


Figure 27-12. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations

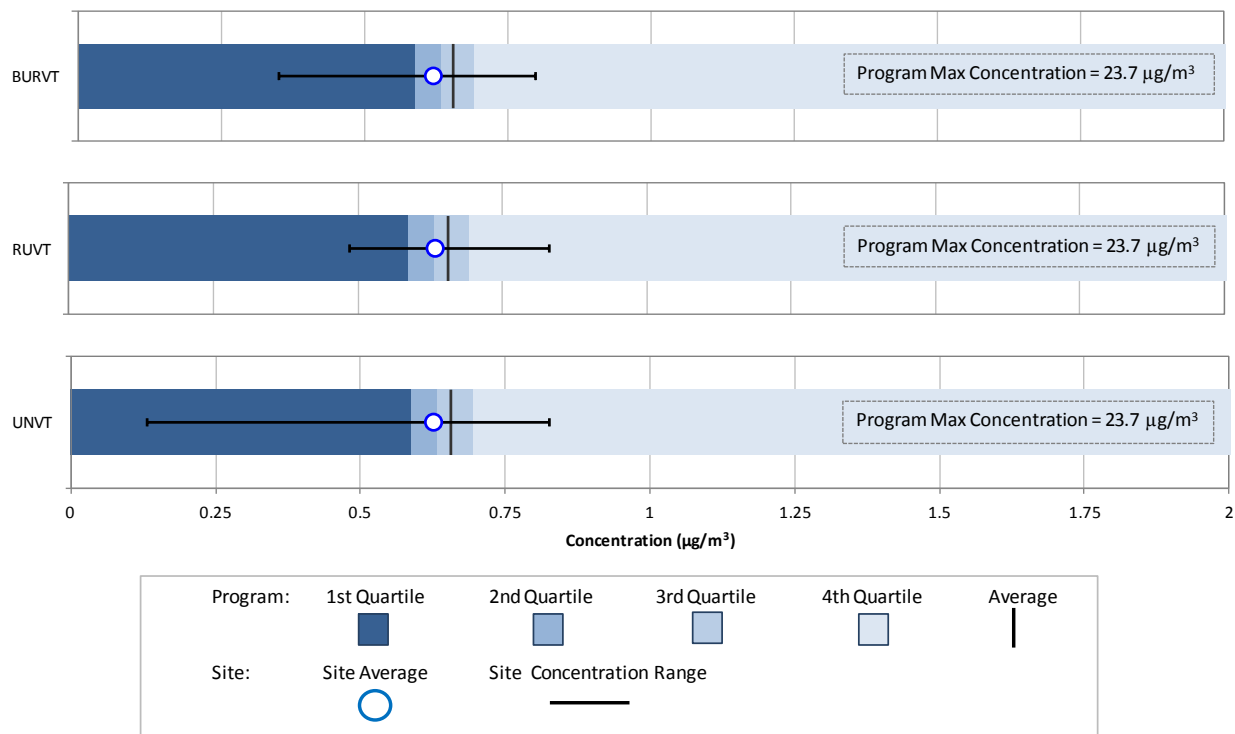


Figure 27-13. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentration

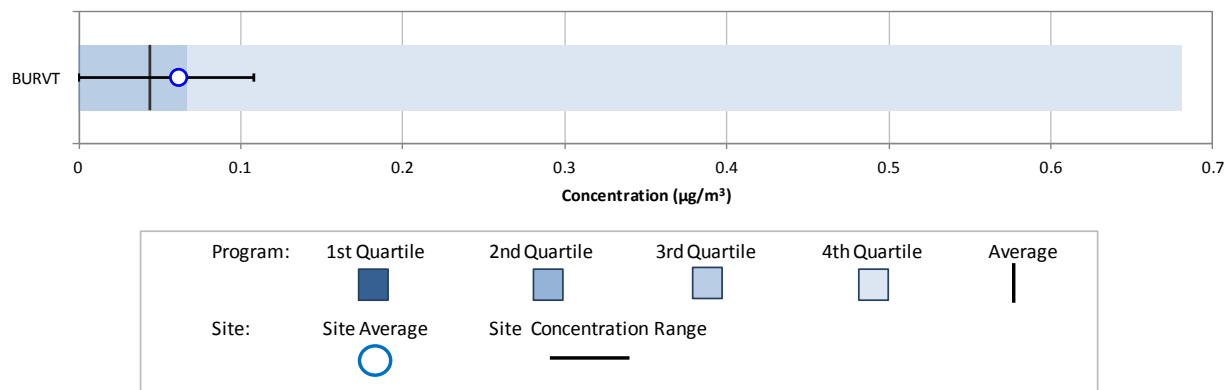


Figure 27-14. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations

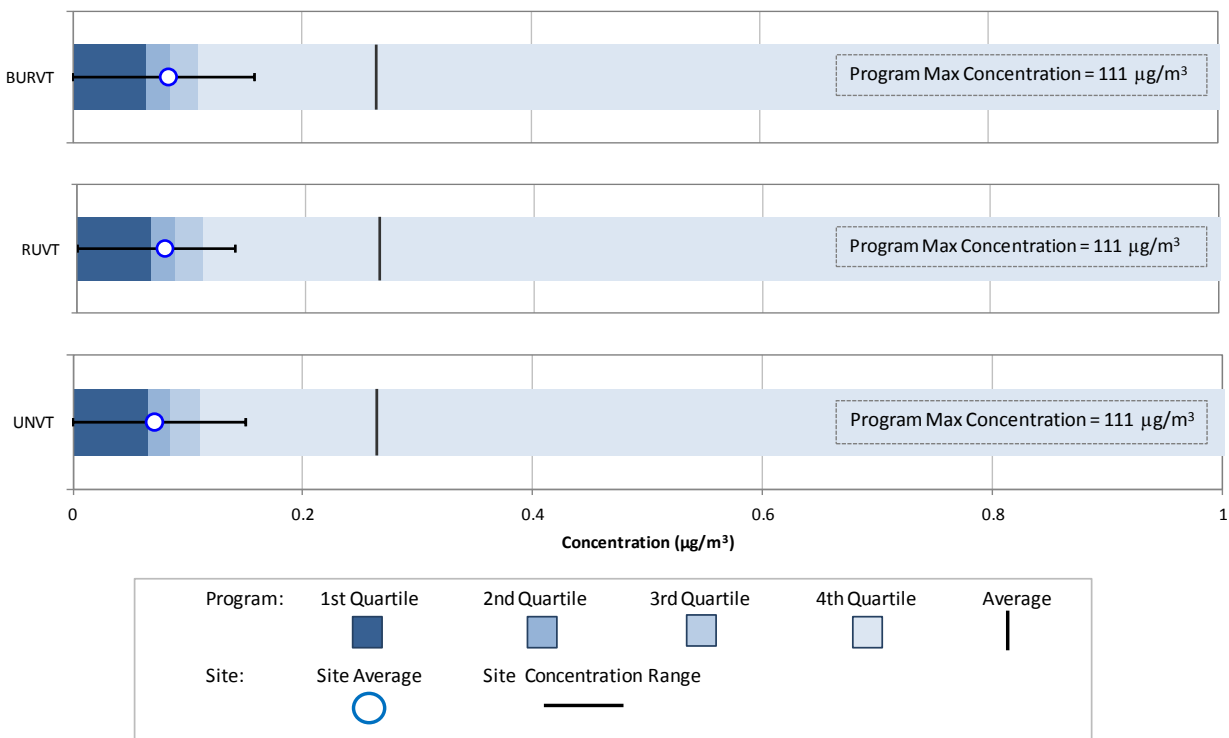


Figure 27-15. Program vs. Site-Specific Average Ethylbenzene Concentration

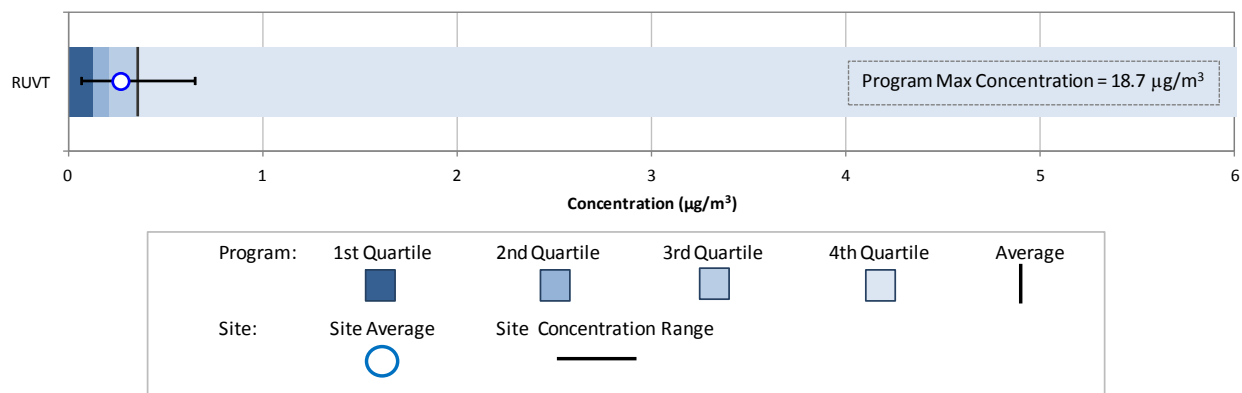
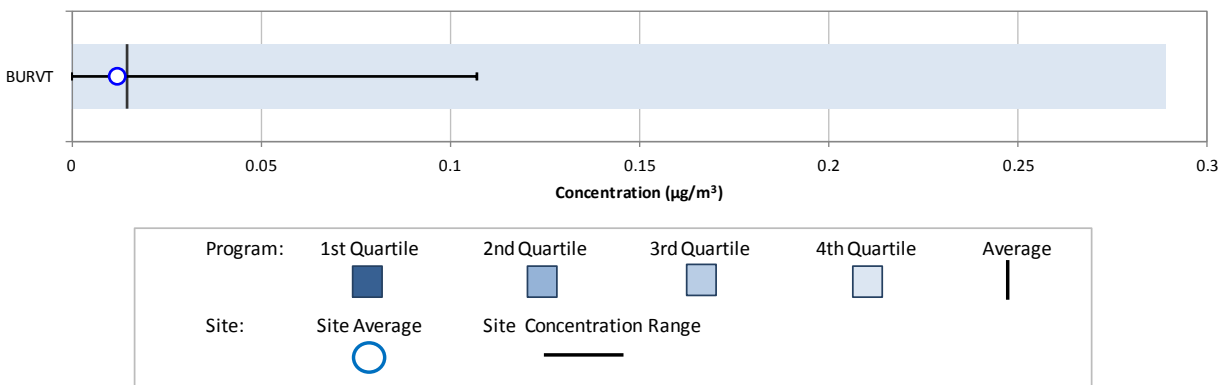


Figure 27-16. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentration



Observations from Figures 27-9 through 27-16 include the following:

- Figure 27-9 presents the box plot for arsenic. UNVT is the only Vermont site that sampled PM₁₀ metals. The maximum arsenic concentration measured at UNVT is less than the program-level third quartile and the only site-specific maximum concentration less than 1 ng/m³. UNVT's annual average arsenic (PM₁₀) concentration is similar to the program-level first quartile (25th percentile). As discussed previously, the annual average concentration of arsenic for UNVT is the lowest annual average arsenic concentration among NMP sites sampling this pollutant.
- Figure 27-10 for benzene shows all three Vermont sites. Note that the program-level maximum concentration (43.5 µg/m³) is not shown directly on the box plots because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plots has been reduced to 12 µg/m³. Even though the range of benzene concentrations is largest for UNVT, this site has the lowest annual average concentration both among the Vermont sites and across the program. The annual average benzene concentration for UNVT is just less than the program-level first quartile. RUVT has the highest annual average concentration of benzene among the Vermont sites. The annual average concentration for RUVT is similar to the program-level average concentration. The smallest range of benzene concentrations was measured at BURVT, whose annual average concentration is less than the program-level average but greater than the program-level median concentration.
- Figure 27-11 for 1,3-butadiene also shows all three sites. Note that the program-level maximum concentration (21.5 µg/m³) is not shown directly on the box plots because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plots has been reduced to 1.5 µg/m³. The range of 1,3-butadiene concentrations is smallest for UNVT and largest for RUVT. The maximum 1,3-butadiene concentration measured at RUVT is greater than the program-level average concentration. The maximum concentration measured at BURVT is less than the program-level average concentration and the maximum concentration measured at UNVT is similar to the program-level median concentration. The annual average

concentration for RUVT is just greater than the program-level third quartile; the annual average concentration for BURVT is just greater than the program-level median concentration; and the annual average for UNVT is the lowest annual average concentration calculated among NMP sites sampling 1,3-butadiene with Method TO-15 and is one-sixth the program-level average concentration. It should be noted however, that the program-level average concentration is an order of magnitude less than the scale of the box plots and is being driven by a few measurements at the upper end of the concentration range.

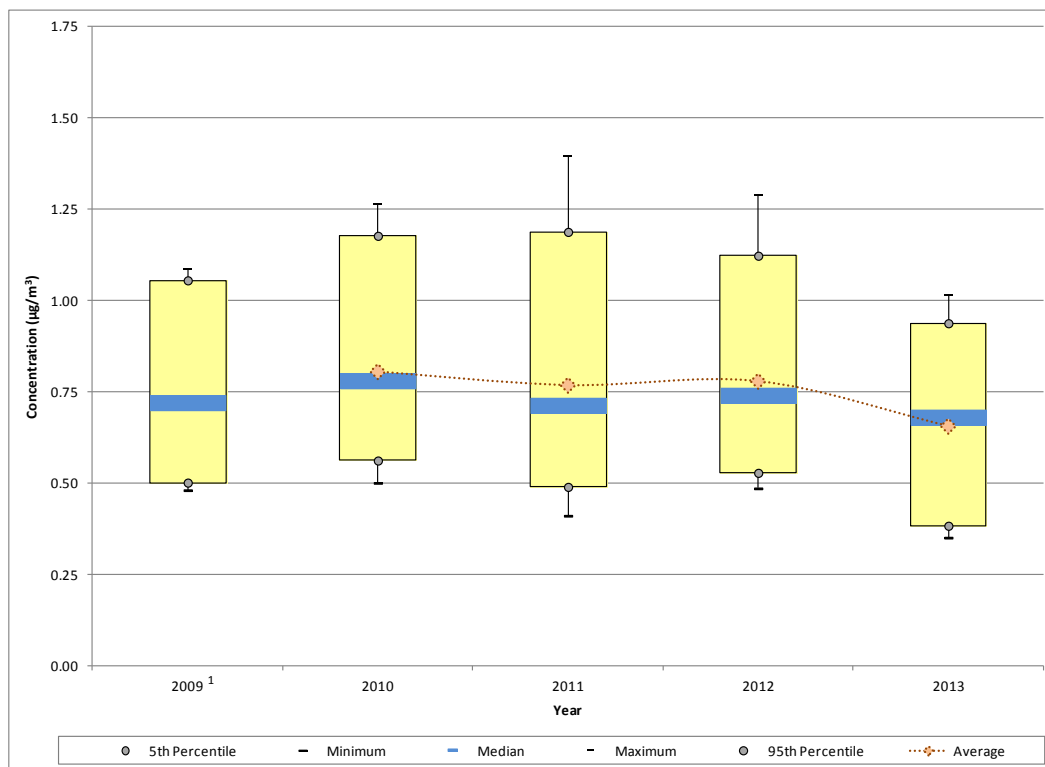
- Figure 27-12 presents the box plots for carbon tetrachloride for all three sites. Similar to other VOCs, the program-level maximum concentration ($23.7 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots as the scale has been reduced to $2 \mu\text{g}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. The maximum concentrations of carbon tetrachloride are similar among the Vermont sites. There is more variability in the minimum concentrations measured at these sites. The annual average concentrations calculated for these sites are similar to each other and the program-level median concentration of carbon tetrachloride.
- Figure 27-13 is the box plot for *p*-dichlorobenzene for BURVT, the only Vermont site for which this pollutant is a pollutant of interest. Note that the first and second quartiles are not visible on the box plot because they are zero due to the large number of non-detects of this pollutant. The maximum concentration measured at BURVT is about one-sixth of the program-level maximum concentration. The annual average concentration for BURVT is greater than the program-level average concentration and just less than the program-level third quartile.
- Figure 27-14 presents the box plots for 1,2-dichloroethane for all three sites. Note that the program-level maximum concentration ($111 \mu\text{g}/\text{m}^3$) is not shown directly on the box plots as the scale has been reduced to $1 \mu\text{g}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. All of the measurements of 1,2-dichloroethane measured at the Vermont sites are less than the program-level average concentration. The program-level average concentration for this pollutant is being driven by the highest concentrations measured at a few monitoring sites. The annual average concentrations of 1,2-dichloroethane for the Vermont sites are similar to each and just less than the median concentration at the program level.
- Figure 27-15 is the box plot for ethylbenzene for RUVT, the only Vermont site for which ethylbenzene is a pollutant of interest. The program-level maximum concentration ($18.7 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot as the scale has been reduced to $6 \mu\text{g}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. The range of ethylbenzene concentrations measured at RUVT is relatively small. The annual average concentration for RUVT falls between the program-level median and average concentrations (and the third quartile).

- Figure 27-16 presents the box plot for hexachloro-1,3-butadiene for BURVT, the only Vermont site for which this pollutant is a pollutant of interest. The first, second, and third quartiles are not visible on the box plot because they are all zero due to the large number of non-detects of this pollutant. This pollutant was detected in only four of the 31 valid VOC samples collected at BURVT in 2013. The maximum concentration of hexachloro-1,3-butadiene measured at BURVT is less than half the maximum concentration measured across the program. The annual average concentration for BURVT is just less than the program-level average concentration.

27.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. UNVT has sampled PM₁₀ metals under the NMP since 2008. In addition, sampling for VOCs under the NMP began at all three Vermont sites in 2009. Thus, Figures 27-17 through 27-32 present the annual statistical metrics for the pollutants of interest for each of the Vermont sites, first for BURVT, then for RUVT and UNVT. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 27-17. Yearly Statistical Metrics for Benzene Concentrations Measured at BURVT

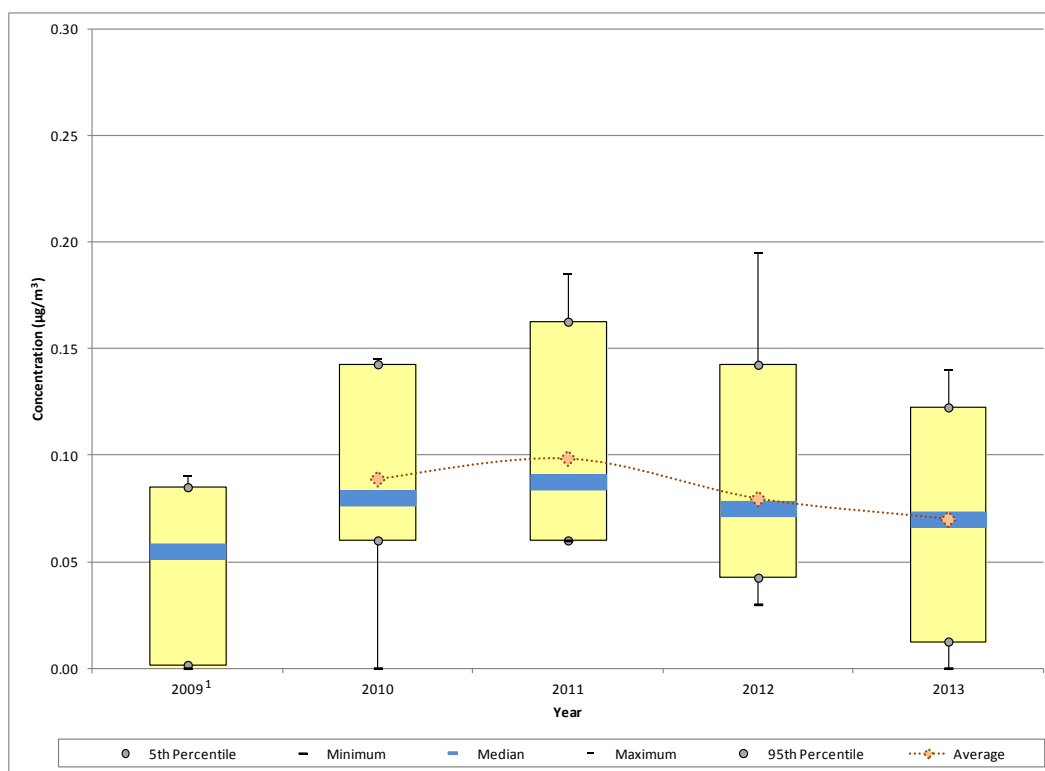


¹ A 1-year average is not presented due to a low completeness for 2009.

Observations from Figure 27-17 for benzene measurements collected at BURVT include the following:

- BURVT began sampling VOCs under the NMP in February 2009. However, a 1-year average concentration is not provided for 2009 because the late start combined with low completeness and a 1-in-12 sampling schedule did not yield enough valid samples. However, the range of concentrations measured in 2009 is still provided.
- The smallest range of benzene concentrations was measured at BURVT in 2009. Although the range of concentrations widened a little each year through 2011, the median concentration calculated for each year through 2012 changed little, hovering on either side of 0.75 $\mu\text{g}/\text{m}^3$. Between 2010 and 2012, the 1-year average concentration did not change significantly, ranging from 0.77 $\mu\text{g}/\text{m}^3$ (2011) and 0.80 $\mu\text{g}/\text{m}^3$ (2010).
- Each of the statistical parameters exhibit a decrease for 2013, with each of them at a minimum for 2013 over the period of sampling shown.

Figure 27-18. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at BURVT

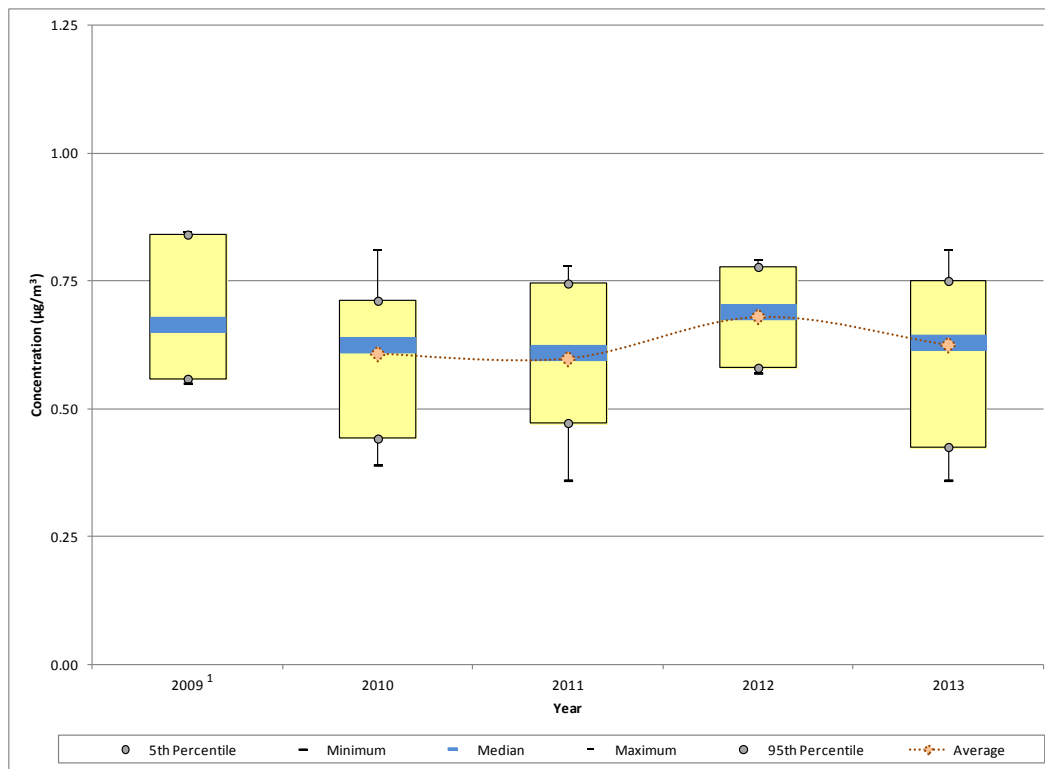


¹ A 1-year average is not presented due to a low completeness for 2009.

Observations from Figure 27-18 for 1,3-butadiene measurements collected at BURVT include the following:

- Concentrations of 1,3-butadiene measured at BURVT in 2009 were all less than $0.10 \mu\text{g}/\text{m}^3$.
- Each of the statistical parameters increased for 2010, with the exception of the minimum concentration, which remained at zero due to a single non-detect measured. For 2010, more than one-third of the concentrations measured were greater than $0.10 \mu\text{g}/\text{m}^3$.
- Further increases in the statistical parameters are shown for 2011, including the minimum concentration as no non-detects were measured. With the exception of the maximum concentration, all of the statistical parameters for 2011 are at a maximum for the period of sampling shown.
- Each of the statistical parameters is shown for 2012 exhibits a decrease from 2011, except the maximum concentration. This is true for 2013 as well. Excluding 2009, each of the statistical parameters are at a minimum for 2013.

Figure 27-19. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at BURVT

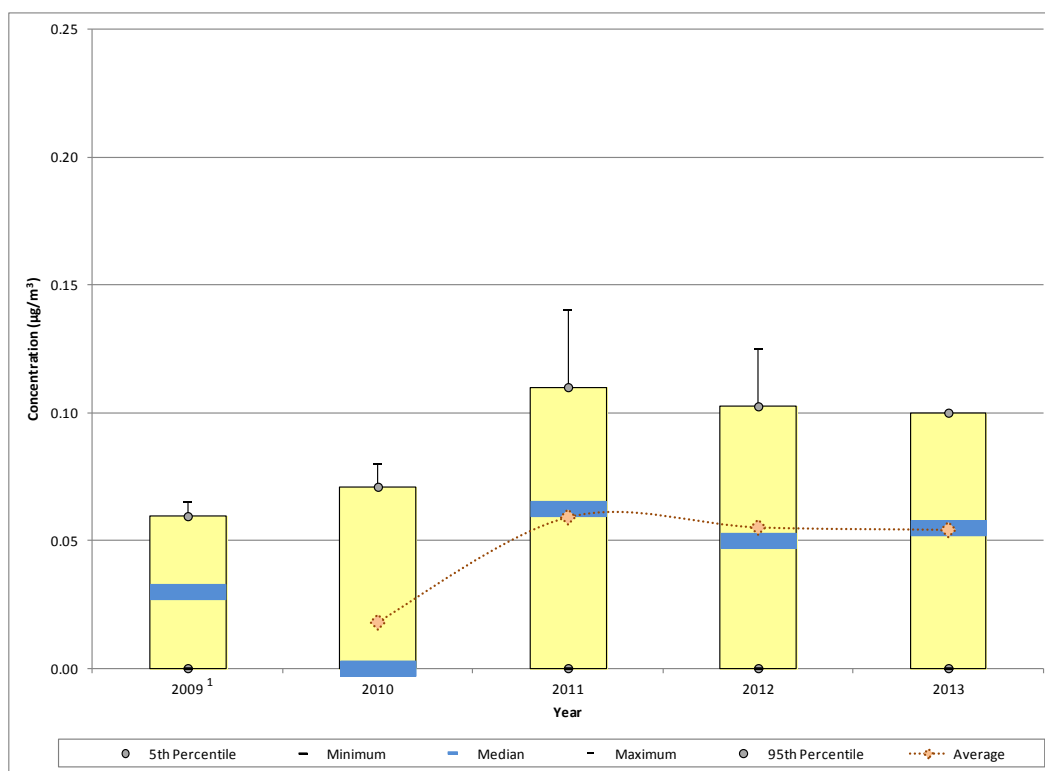


¹ A 1-year average is not presented due to a low completeness for 2009.

Observations from Figure 27-19 for carbon tetrachloride measurements collected at BURVT include the following:

- The carbon tetrachloride concentrations measured at BURVT since 2009 vary by less than $0.5 \mu\text{g}/\text{m}^3$. The maximum concentration ($0.845 \mu\text{g}/\text{m}^3$) was measured in 2009 and the minimum concentration ($0.360 \mu\text{g}/\text{m}^3$) was measured in 2011 and again in 2013.
- The median concentrations calculated for each year of sampling span less than $0.1 \mu\text{g}/\text{m}^3$, ranging from $0.61 \mu\text{g}/\text{m}^3$ (2011) and $0.69 \mu\text{g}/\text{m}^3$ (2012). This is also true for the 1-year average concentration, which ranges from $0.60 \mu\text{g}/\text{m}^3$ (2011) to $0.68 \mu\text{g}/\text{m}^3$ (2012).
- The concentrations measured in 2010, 2011, and 2013 are fairly similar. The range of measurements is considerably tighter for 2012, as little change in the maximum concentration is shown and nine concentrations measured in 2011 are less than the minimum concentration measured in 2012. But the increase in the statistical parameters shown is not just a result of a higher minimum concentration; concentrations were higher overall in 2012. The number of carbon tetrachloride concentrations greater than or equal to $0.7 \mu\text{g}/\text{m}^3$ measured at BURVT increased from three in 2011 to 14 for 2012, accounting for nearly half of the measurements for 2012. The next highest year has five (both 2009 and 2013).

Figure 27-20. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at BURVT

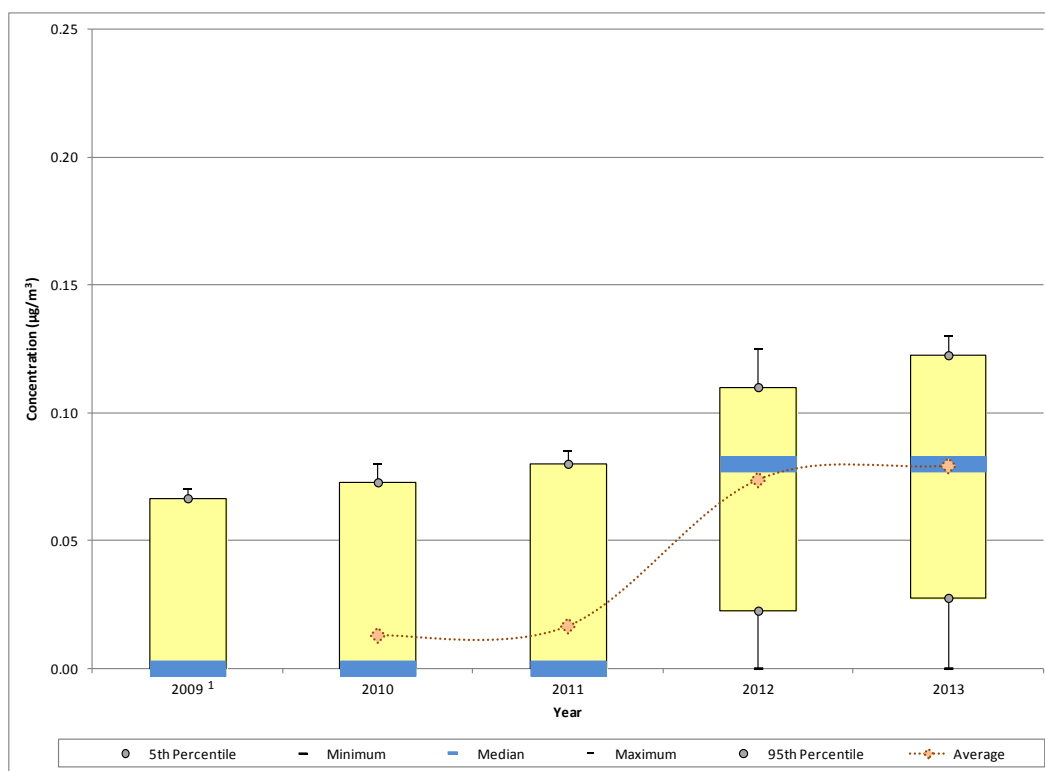


¹ A 1-year average is not presented due to a low completeness for 2009.

Observations from Figure 27-20 for *p*-dichlorobenzene measurements collected at BURVT include the following:

- The minimum and 5th percentile for each year shown in Figure 27-20 is zero, indicating that at least 5 percent of the measurements were non-detects for each year. The median concentration is also zero for 2010, indicating that at least half of the measurements for 2010 were non-detects. The percentage of non-detects has varied from 10 percent (2012) to 63 percent (2010).
- The maximum and 95th percentile increased each year between 2009 and 2011, when the highest *p*-dichlorobenzene concentration was measured ($0.14 \mu\text{g}/\text{m}^3$). These parameters have a decreasing slight trend in the years that follow.
- Both the 1-year average and median concentrations increased significantly from 2010 to 2011. Not only did the number of non-detects decrease considerably (from 63 percent to 17 percent), six concentrations greater than the maximum concentration for 2010 were measured in 2011.
- Despite the slight decreases shown in the upper end of the concentration range shown for 2012 and 2013, the 1-year average and median concentrations did not change significantly.

Figure 27-21. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at BURVT

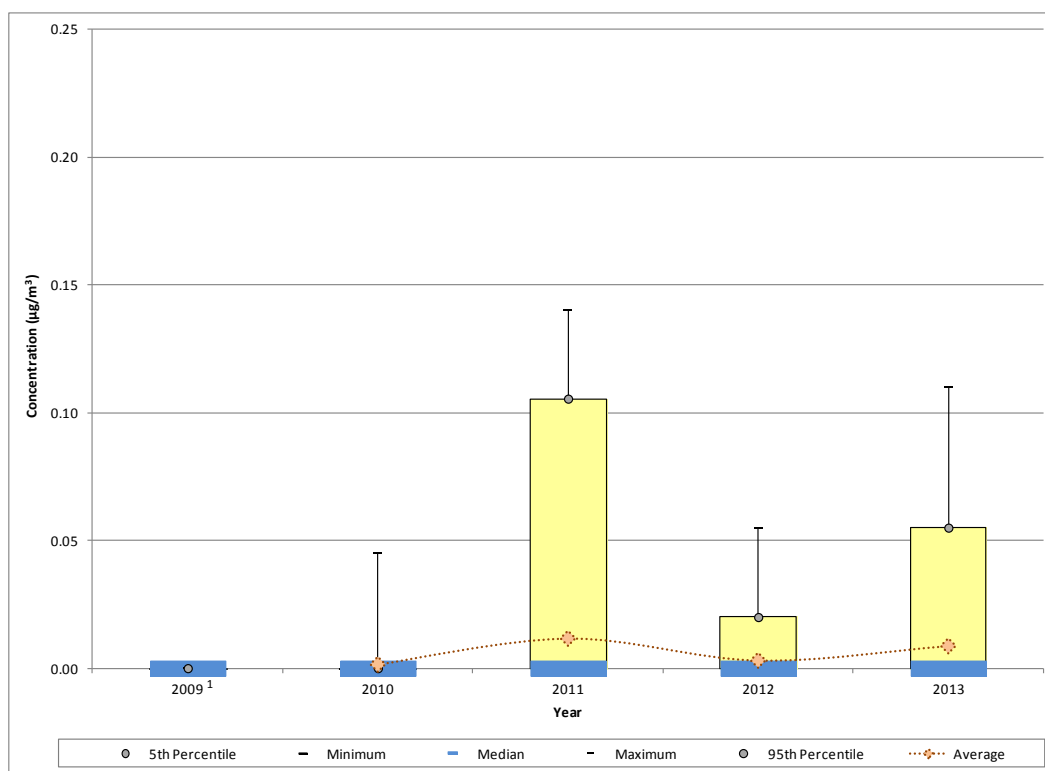


¹ A 1-year average is not presented due to a low completeness for 2009.

Observations from Figure 27-21 for 1,2-dichloroethane measurements collected at BURVT include the following:

- The minimum, 5th percentile, and median concentration for each year shown through 2011 in Figure 27-21 is zero, indicating that at least half of the measurements for each year through 2011 were non-detects. The percentage of non-detects measured at BURVT has decreased each year, from a maximum of 91 percent to a minimum of 3 percent. A sharp decrease in the number of non-detects occurred between 2011, when the percentage of non-detects was at 77 percent, and 2012, when the percentage of non-detects fell to 6 percent. This change is reflected in the statistical parameters representing the lower end of the concentration range for 2012 as well as those representing the central tendency statistics of the dataset.
- The 95th percentile and maximum concentrations have increased (albeit slightly) each year of sampling. Thus, magnitude of the concentrations at the upper end of the concentration range have also increased over the course of sampling.

Figure 27-22. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at BURVT

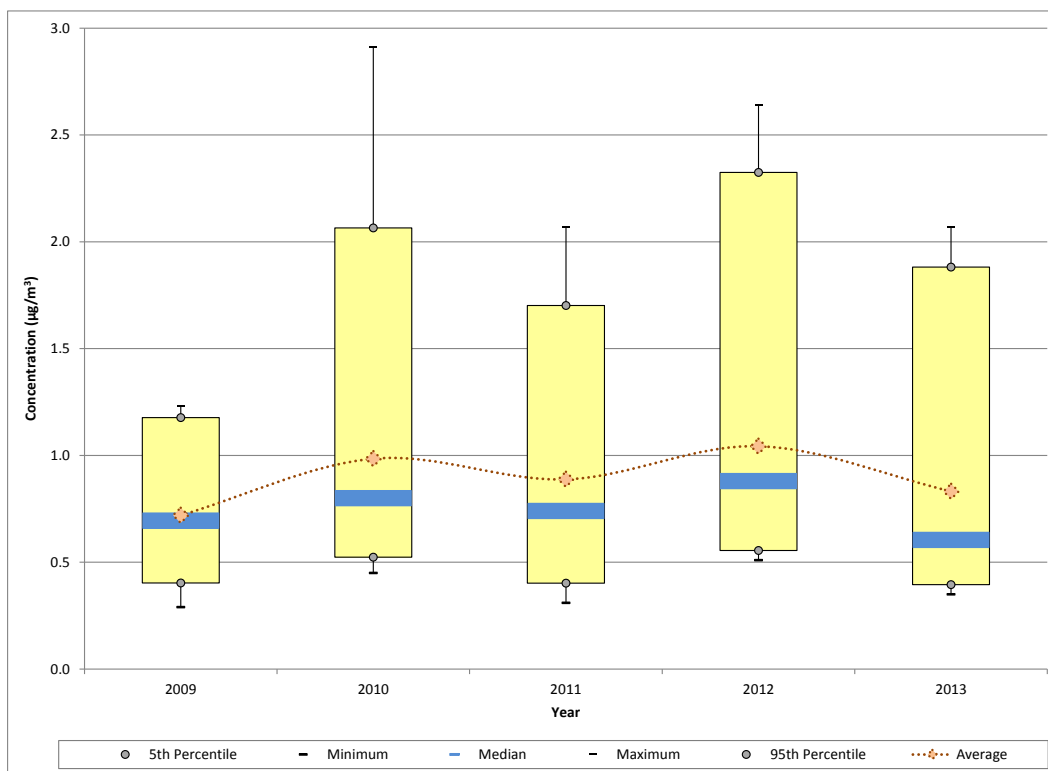


¹ A 1-year average is not presented due to a low completeness for 2009.

Observations from Figure 27-22 for hexachloro-1,3-budadiene measurements collected at BURVT include the following:

- The minimum, 5th percentile, and median concentration for each year shown in Figure 27-22 is zero, indicating that at least half of the measurements for each year were non-detects. In fact, all of the measurements were non-detects for 2009 and all but one were non-detects for 2010.
- Between 2011 and 2013, the percentage of non-detects ranged from 87 percent (2013) to 94 percent (2012), still accounting for the majority of measurements. No more than four measured detections of hexachloro-1,3-budadiene have been measured at BURVT in any given year.

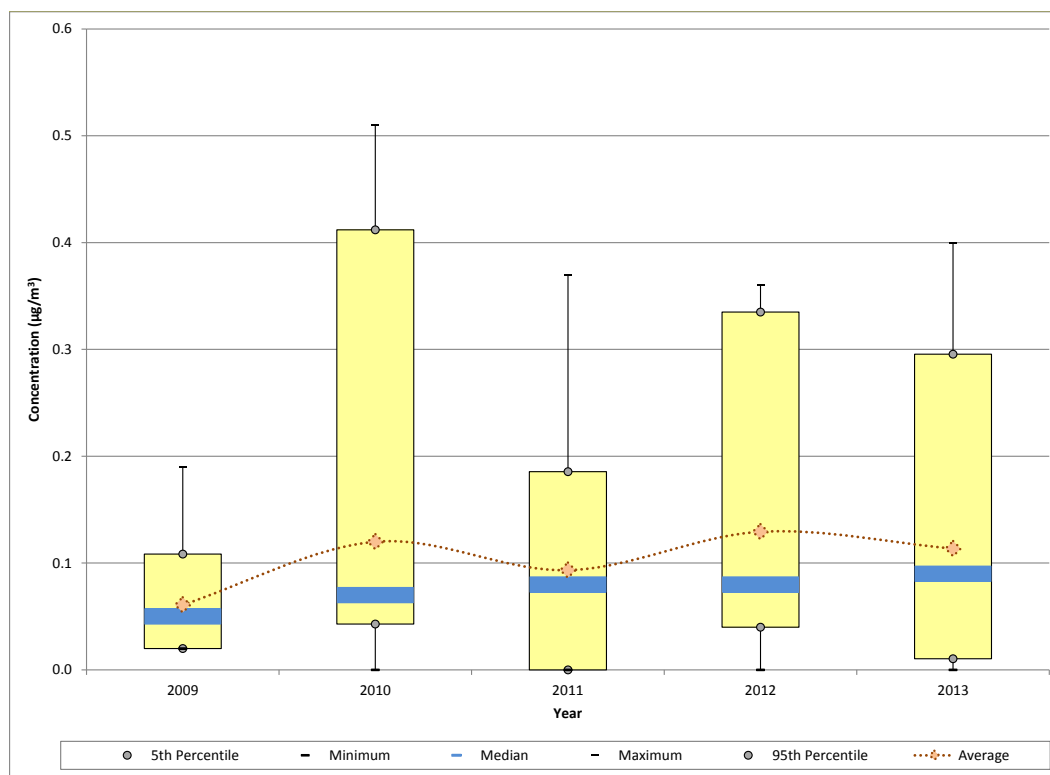
Figure 27-23. Yearly Statistical Metrics for Benzene Concentrations Measured at RUVT



Observations from Figure 27-23 for benzene measurements collected at RUVT include the following:

- Sampling for VOCs at RUVT under the NMP also began in February 2009.
- The maximum benzene concentration was measured at RUVT in 2010 ($2.91 \mu\text{g}/\text{m}^3$). Six additional benzene concentrations greater than $2 \mu\text{g}/\text{m}^3$ have been measured at RUVT, at least one in each year, with the exception of 2009.
- The maximum concentration doubled from 2009 to 2010 and the 95th percentile increased by 75 percent. The other statistical parameters also exhibit increases. The number of benzene concentrations greater than $0.75 \mu\text{g}/\text{m}^3$ doubled from eight in 2009 to 16 for 2010, accounting for 60 percent of the measurements in 2010.
- Years with higher benzene concentrations alternate with years with lower concentrations, giving the box and whisker plots an undulating pattern. The 1-year average concentrations have varied from $0.72 \mu\text{g}/\text{m}^3$ (2009) to $1.04 \mu\text{g}/\text{m}^3$ (2012); the median concentrations have varied from $0.61 \mu\text{g}/\text{m}^3$ (2009) to $0.88 \mu\text{g}/\text{m}^3$ (2012).

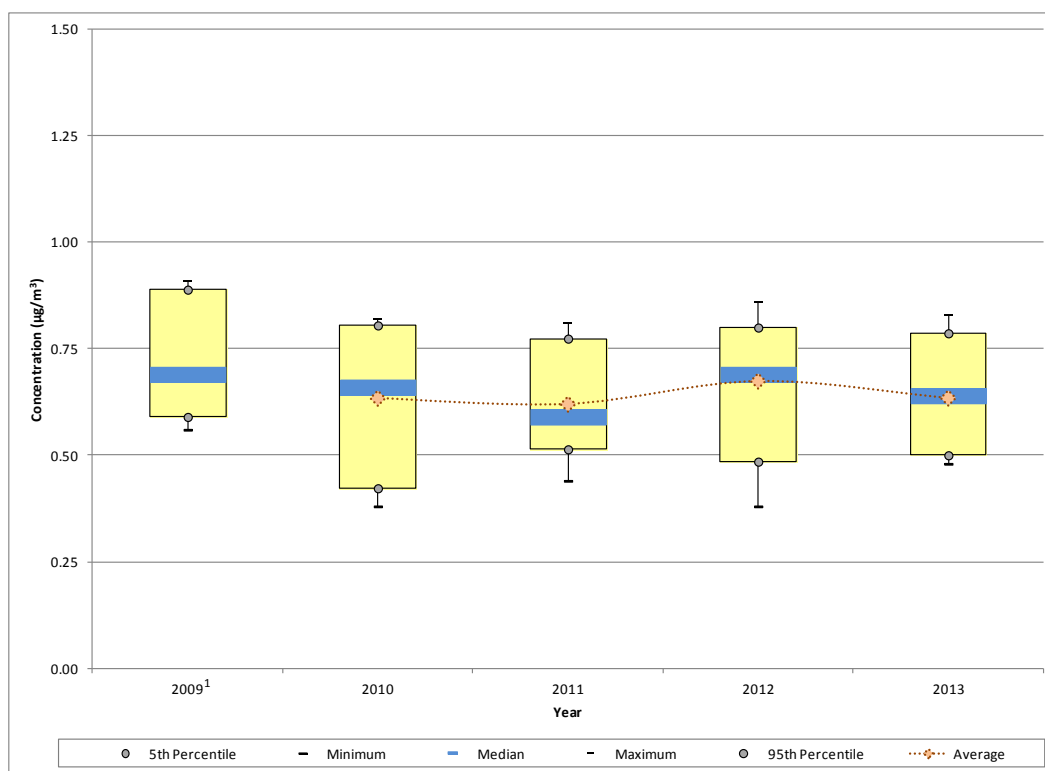
Figure 27-24. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at RUVT



Observations from Figure 27-24 for 1,3-butadiene measurements collected at RUVT include the following:

- At least one non-detect of 1,3-butadiene was measured at RUVT each year of sampling, with the exception of 2009. The number of non-detects has ranged from zero (2009) to five (2011).
- The 1-year average concentration for 2010 is greater than the 95th percentile for 2009, indicating that concentrations measured in 2010 were higher than those measured in 2009. The number of 1,3-butadiene concentrations greater than or equal to $0.1 \mu\text{g}/\text{m}^3$ increased from four in 2009 to 10 for 2010. While the range of 1,3-butadiene concentrations measured tripled from 2009 to 2010 and the 1-year average concentration doubled, the increase in the median concentration is less dramatic.
- The box and whisker plot for 1,3-butadiene resembles the box and whisker plot for benzene, with a similar undulating pattern from year to year. The 1-year average concentration has ranged from $0.06 \mu\text{g}/\text{m}^3$ (2009) to $0.13 \mu\text{g}/\text{m}^3$ (2012) while the median has ranged from $0.05 \mu\text{g}/\text{m}^3$ (2009) to $0.09 \mu\text{g}/\text{m}^3$ (2013).

Figure 27-25. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at RUVT



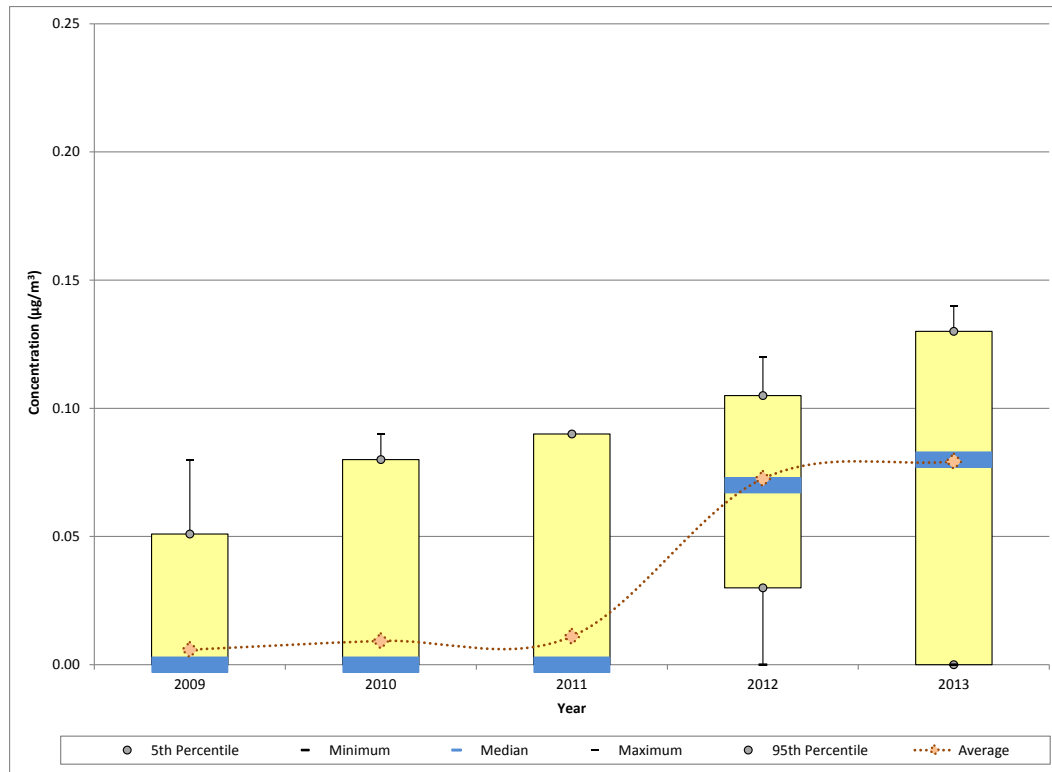
¹ A 1-year average is not presented due to low completeness in 2009.

Observations from Figure 27-25 for carbon tetrachloride measurements collected at RUVT include the following:

- A few individual carbon tetrachloride concentrations from valid VOC samples were invalidated in 2009, resulting in a completeness less than 85 percent. As a result, a 1-year average concentration is not presented, although the range of measurements is still provided.
- Concentrations of carbon tetrachloride measured at RUVT since 2009 span a relatively small range, with a minimum concentration of 0.38 µg/m³ (2010 and 2012) and a maximum concentration of 0.91 µg/m³ (2009). Five of the six highest carbon tetrachloride concentrations (those greater than 0.85 µg/m³) were measured in 2009.
- All of the statistical parameters exhibit a decrease from 2009 to 2010. Five concentrations measured in 2009 are greater than the maximum concentration measured in 2010 and six concentrations measured in 2010 are less than the minimum concentration measured in 2009. Yet, the decrease in the median concentration is relatively small, from 0.69 µg/m³ for 2009 to 0.66 µg/m³ for 2010.
- The majority of concentrations, as indicated by the 5th and 95th percentiles, fell into a tighter range for 2011, with similar ranges in the years that follow. Most of the

measurements collected at RUVT between 2011 and 2013 fell between roughly $0.5 \mu\text{g}/\text{m}^3$ and $0.8 \mu\text{g}/\text{m}^3$.

Figure 27-26. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at RUVT

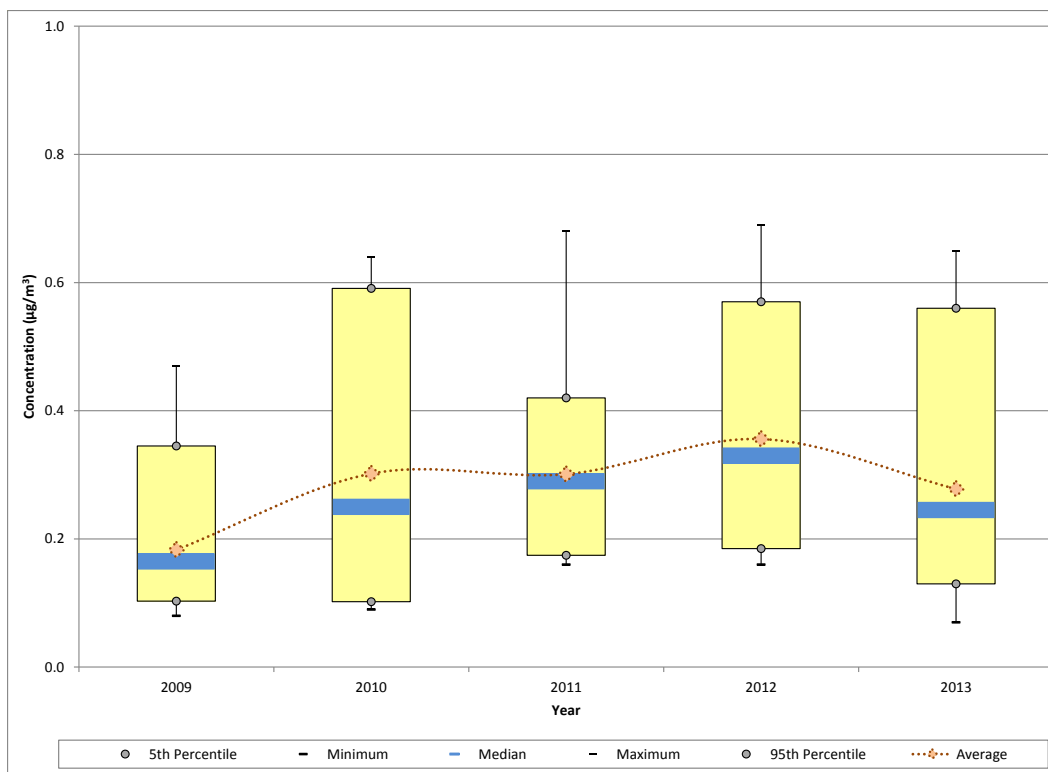


Observations from Figure 27-26 for 1,2-dichloroethane measurements collected at RUVT include the following:

- The box and whisker plot for 1,2-dichloroethane for RUVT resembles the box and whisker plot for 1,2-dichloroethane for BURVT.
- The minimum, 5th percentile, and median concentration for each year through 2011 are zero, indicating that at least half of the measurements for each year through 2011 were non-detects. The percentage of non-detects measured at RUVT during the first 3 years of sampling ranged from 87 percent (2011) to 92 percent (2009). A sharp decrease in the number of non-detects occurred after 2011. Only two non-detects were measured in 2012 and three non-detects were measured in 2013. This decrease in non-detects (and thus, zeros substituted in the calculations) is reflected in the statistical parameters for these years, particularly in the central tendency statistics of the dataset.
- The 95th percentile and maximum concentrations have increased each year, with the exception of 2011, which exhibits no change. Thus, magnitude of the concentrations

at the upper end of the concentration range have also increased over the course of sampling.

Figure 27-27. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at RUVT

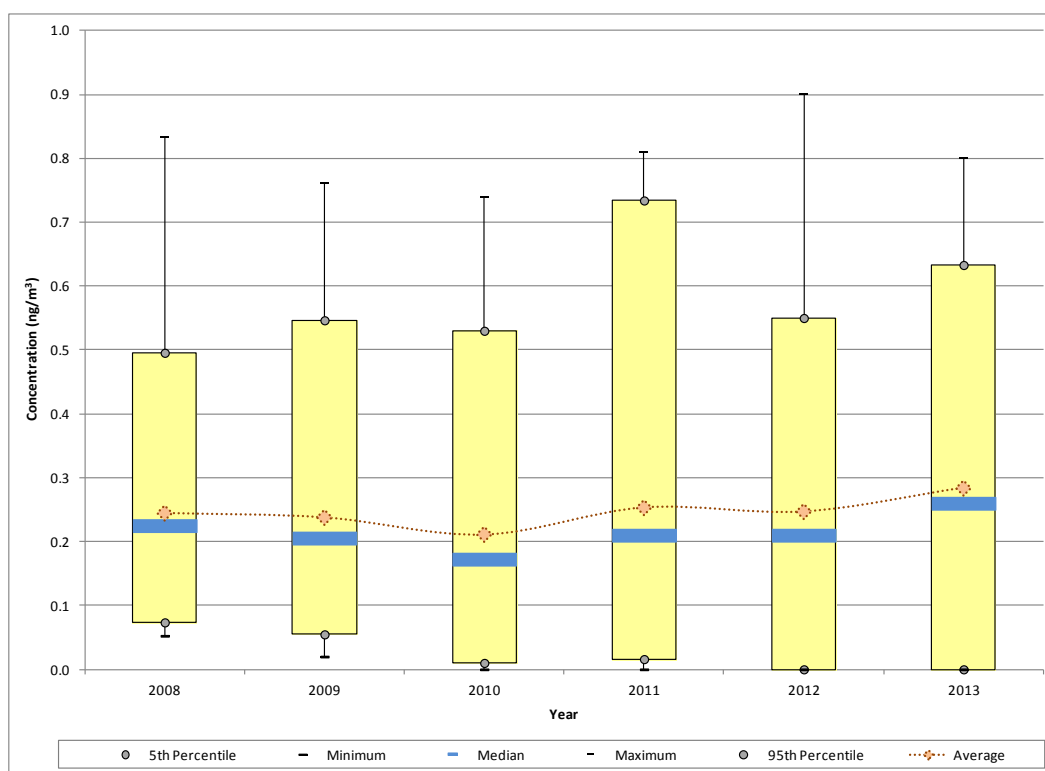


Observations from Figure 27-27 for ethylbenzene measurements collected at RUVT include the following:

- The maximum benzene concentration was measured at RUVT in 2012 ($0.69 \mu\text{g}/\text{m}^3$), although similar concentrations have been in each year of sampling, with the exception of 2009, when no concentrations greater than $0.5 \mu\text{g}/\text{m}^3$ were measured.
- The 1-year average concentration for 2010 is significantly greater than the 1-year average concentration for 2009. Six ethylbenzene concentrations measured in 2010 are greater than the maximum concentration measured in 2009 while concentrations at the lower end of the concentration range changed little. Nearly 88 percent of the ethylbenzene concentrations measured in 2009 are less than $0.25 \mu\text{g}/\text{m}^3$, which is the median concentration for 2010.
- The median concentration has an increasing trend between 2009 and 2012, nearly doubling from $0.17 \mu\text{g}/\text{m}^3$ for 2009 to $0.33 \mu\text{g}/\text{m}^3$ for 2012. The 1-year average concentration has a similar pattern, with the exception of 2011, for which virtually no change is shown.

- For 2013, the measurements at the upper end of the concentration range changed little, but a decrease is shown at the lower end of the concentration range. Six concentrations measured in 2013 are less than the minimum concentration measured in 2012 and the number of ethylbenzene concentrations less than $0.25 \mu\text{g}/\text{m}^3$ doubled from 2012 (seven) to 2013 (14), accounting for half of the measurements collected in 2013. This explains the decreases shown in the 1-year average and median concentrations.

Figure 27-28. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at UNVT

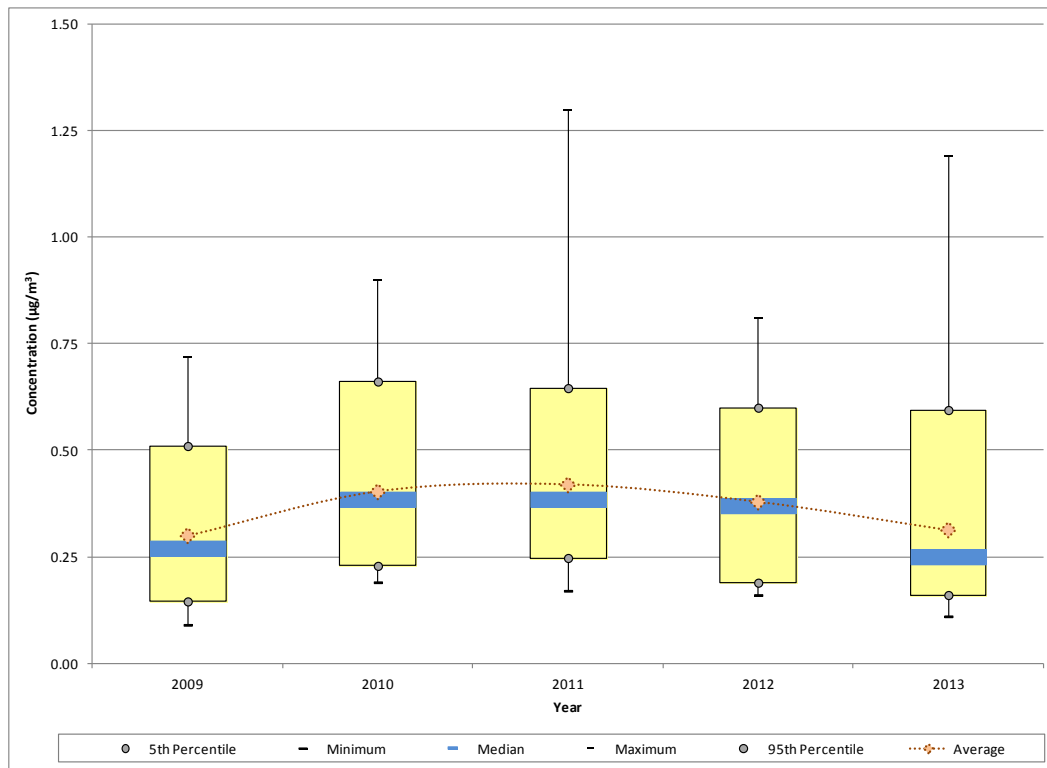


Observations from Figure 27-28 for arsenic measurements collected at UNVT include the following:

- The maximum arsenic concentration was measured at UNVT in 2012 ($0.90 \text{ ng}/\text{m}^3$).
- With the exception of the 95th percentile, each of the statistical parameters exhibits a slight decreasing trend between 2008 and 2010. The minimum concentration in 2008 was $0.05 \text{ ng}/\text{m}^3$, which decreased to $0.02 \text{ ng}/\text{m}^3$ for 2009, and the first non-detects were measured in 2010 (three). Between three and six non-detects were measured each year following 2010.
- Overall, a similar range of arsenic concentrations have been measured at UNVT each year. The 1-year average concentrations of arsenic for UNVT have changed little over the years of sampling, ranging from $0.21 \text{ ng}/\text{m}^3$ (2010) to $0.28 \text{ ng}/\text{m}^3$ (2013).

Likewise, the median concentration has ranged from 0.17 ng/m³ (2010) to 0.26 ng/m³ (2013).

Figure 27-29. Yearly Statistical Metrics for Benzene Concentrations Measured at UNVT

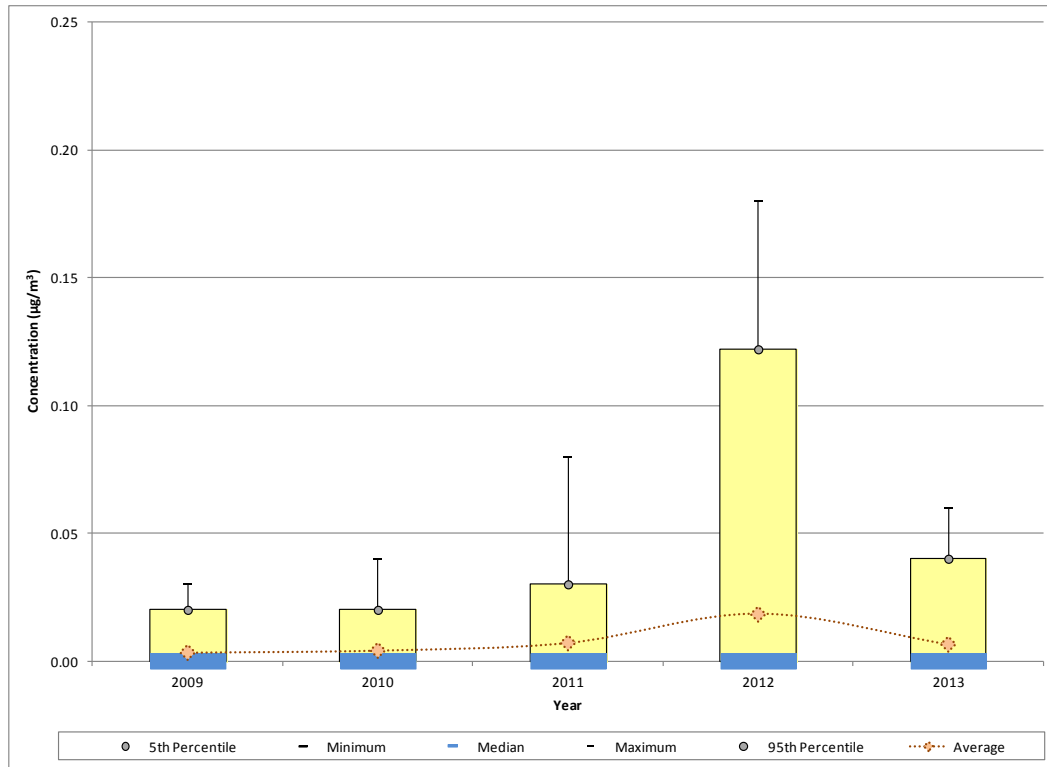


Observations from Figure 27-29 for benzene measurements collected at UNVT include the following:

- Only two benzene concentrations greater than 1.0 µg/m³ have been measured at UNVT, one in 2011 (1.30 µg/m³) and one in 2013 (1.19 µg/m³).
- All of the statistical parameters exhibit increases from 2009 to 2010, with the largest increases shown for the maximum and 95th percentile. Despite the higher maximum concentration for 2011, little change is shown in most of the statistical parameters for 2011.
- All of the statistical parameters exhibit decreases from 2011 to 2012, although the differences are small for most of them.
- Even though the second highest benzene concentration was measured in 2013, the 1-year average concentration is at its lowest since 2009 and the median concentration is at a minimum over the period of sampling. This is due to an increase in the measurements at the lower end of the concentration range. The number of benzene concentrations less than 0.3 µg/m³ more than doubled, from 17 in 2012 to 37 in 2013,

accounting for nearly 64 percent of the concentrations for 2013. No other year has more than 30 and most years have fewer than 20.

Figure 27-30. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at UNVT

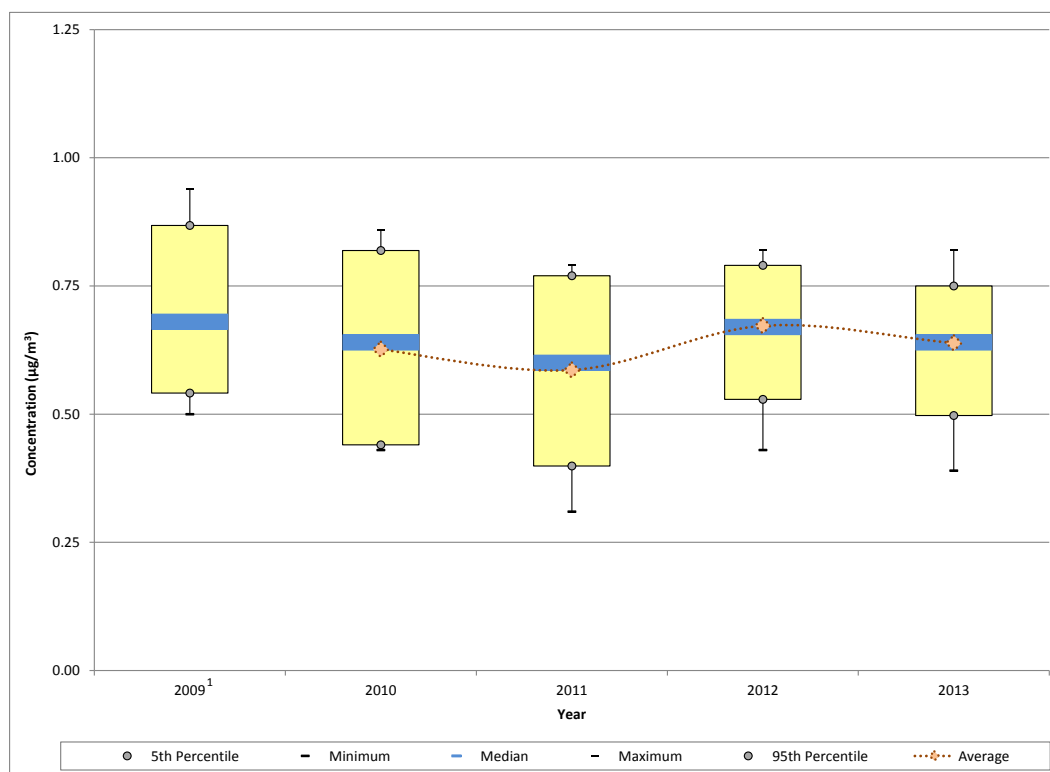


Observations from Figure 27-30 for 1,3-butadiene measurements collected at UNVT include the following:

- The median 1,3-butadiene concentration (along with the minimum and 5th percentile) is zero for all years of sampling, indicating that at least half of the measurements were non-detects. The percentage of non-detects has ranged from 76 percent (2012) to 81 percent (2013).
- The 1-year average concentration, the 95th percentile, and the maximum concentration exhibit increases for each year of sampling between 2009 and 2012, with the largest increase shown for 2012. Prior to 2011, no 1,3-butadiene concentrations greater than 0.05 $\mu\text{g}/\text{m}^3$ were measured at UNVT; in 2011, two concentrations greater than 0.05 $\mu\text{g}/\text{m}^3$ were measured. Prior to 2012, no 1,3-butadiene concentrations greater than 0.10 $\mu\text{g}/\text{m}^3$ were measured at UNVT; in 2012, six concentrations greater than 0.10 $\mu\text{g}/\text{m}^3$ were measured. The measurements collected in 2013 more resemble those measured in 2011, when only one concentration greater than 0.05 $\mu\text{g}/\text{m}^3$ was measured.

- The 1-year average concentrations reflect the increases in the magnitude of the 1,3-butadiene measurements collected at UNVT. Yet, measured detections account for fewer than one-quarter of the measurements collected at UNVT for any given year.

Figure 27-31. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at UNVT



¹ A 1-year average is not presented due to low completeness in 2009

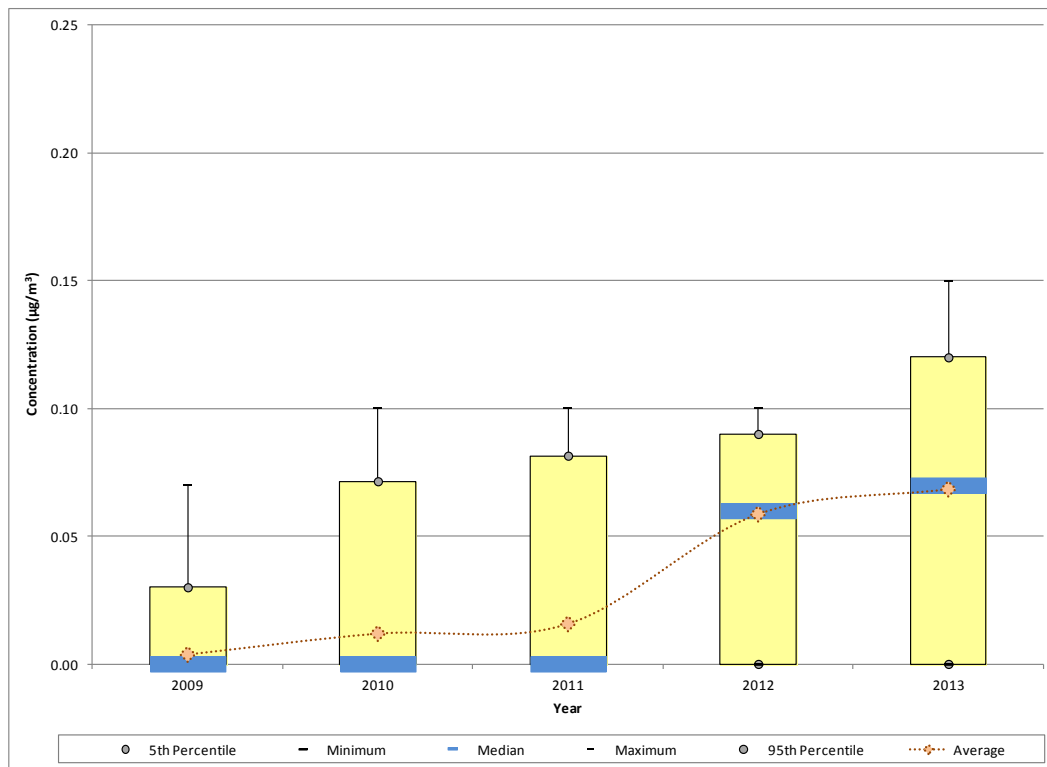
Observations from Figure 27-31 for carbon tetrachloride measurements collected at UNVT include the following:

- A few individual carbon tetrachloride concentrations from valid VOC samples were invalidated in 2009, resulting in a completeness less than 85 percent. As a result, a 1-year average concentration is not presented for 2009, although the range of measurements is still provided.
- All of the statistical parameters shown exhibit a decreasing trend through 2011, when each parameter is at a minimum over the period of sampling.
- All of the statistical parameters increased for 2012, including a statistically significant increase in the 1-year average concentration. These changes are the result of an increase in the number of concentrations at the upper end of the concentration range as well as fewer concentrations at the lower end of the concentration range. The number of carbon tetrachloride concentrations greater than or equal to 0.7 µg/m³ tripled from

eight in 2011 to 24 in 2012. At the lower end of the concentration range, the number of concentrations less than $0.5 \mu\text{g}/\text{m}^3$ decreased from 10 in 2011 to only one in 2012. The minimum concentration measured in 2012 is greater than five of the lower concentrations measured in 2011.

- Although the range of concentrations measured is similar between 2012 and 2013, slight decreases are shown in the central tendency statistics for 2013. The number of carbon tetrachloride concentrations greater than $0.7 \mu\text{g}/\text{m}^3$ decreased by half (down to 12 in 2013 from 24 in 2012).

Figure 27-32. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at UNVT



Observations from Figure 27-32 for 1,2-dichloroethane measurements collected at UNVT include the following:

- The box and whisker plot for 1,2-dichloroethane for UNVT resembles the box and whisker plots for 1,2-dichloroethane for BURVT and RUVT.
- The minimum, 5th percentile, and median concentration for each year shown through 2011 in Figure 27-32 are zero, indicating that at least half of the measurements for each year through 2011 were non-detects. The percentage of non-detects measured at UNVT has decreased each year of sampling, from a maximum of 94 percent in 2009 to a minimum of 12 percent in 2013. A sharp decrease in the number of non-detects occurred after 2011. This decrease in non-detects (and thus, zeros substituted in the

calculations) is reflected in the statistical parameters for these years, particularly in the central tendency statistics of the dataset.

- The 95th percentile has increased for each year of sampling. The maximum concentration increased from 2009 to 2010, did not change through 2012, then increased again for 2013. Thus, the magnitude of concentrations at the upper end of the concentration range have also increased over the course of sampling. However, the overall concentration range is relatively small.

27.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the Vermont monitoring sites. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

27.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Vermont monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 27-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 27-6. Risk Approximations for the Vermont Monitoring Sites

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Burlington, Vermont - BURVT						
Benzene	0.0000078	0.03	31/31	0.65 ± 0.06	5.06	0.02
1,3-Butadiene	0.00003	0.002	30/31	0.07 ± 0.01	2.20	0.04
Carbon Tetrachloride	0.000006	0.1	31/31	0.62 ± 0.03	3.72	0.01
<i>p</i> -Dichlorobenzene	0.000011	0.8	27/31	0.06 ± 0.01	0.68	<0.01
1,2-Dichloroethane	0.000026	2.4	30/31	0.08 ± 0.01	2.17	<0.01
Hexachloro-1,3-butadiene	0.000022	0.09	4/31	0.01 ± 0.01	0.26	<0.01
Rutland, Vermont - RUVT						
Benzene	0.0000078	0.03	31/31	0.81 ± 0.18	6.29	0.03
1,3-Butadiene	0.00003	0.002	29/31	0.11 ± 0.03	3.33	0.06
Carbon Tetrachloride	0.000006	0.1	31/31	0.63 ± 0.03	3.80	0.01
1,2-Dichloroethane	0.000026	2.4	27/31	0.08 ± 0.01	1.99	<0.01
Ethylbenzene	0.0000025	1	31/31	0.27 ± 0.05	0.67	<0.01
Underhill, Vermont - UNVT						
Benzene	0.0000078	0.03	60/60	0.37 ± 0.12	2.86	0.01
1,3-Butadiene	0.00003	0.002	11/60	0.01 ± <0.01	0.19	<0.01
Carbon Tetrachloride	0.000006	0.1	60/60	0.63 ± 0.03	3.76	0.01
1,2-Dichloroethane	0.000026	2.4	53/60	0.07 ± 0.01	1.84	<0.01
Arsenic (PM ₁₀) ^a	0.0043	0.000015	56/60	0.28 ± 0.05	1.22	0.02

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

Observations from Table 27-6 include the following:

- For BURVT, benzene and carbon tetrachloride have the highest annual average concentrations. These two pollutants also have the highest cancer risk approximations for BURVT (5.06 in-a-million and 3.72 in-a-million, respectively).
- Benzene and carbon tetrachloride also have the highest annual average concentrations for RUVT. These pollutants have the highest cancer risk approximations for RUVT

(6.29 in-a-million and 3.80 in-a-million, respectively), although a similar cancer risk approximation was calculated for 1,3-butadiene (3.33 in-a-million).

- Carbon tetrachloride has the highest annual average concentration for UNVT, followed by benzene. These two pollutants have the highest cancer risk approximations for UNVT (3.76 in-a-million for carbon tetrachloride and 2.86 in-a-million for benzene).
- The noncancer hazard approximations for the pollutants of interest for all three Vermont sites are all considerably less than 1.0, indicating that no adverse noncancer health effects are expected from these individual pollutants.

27.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 27-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 27-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 27-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 27-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 27-7. Table 27-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 27.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 27-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Vermont Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Burlington, Vermont (Chittenden County) - BURVT					
Benzene	103.48	Formaldehyde	8.77E-04	Benzene	5.06
Formaldehyde	67.43	Benzene	8.07E-04	Carbon Tetrachloride	3.72
Acetaldehyde	37.96	1,3-Butadiene	4.06E-04	1,3-Butadiene	2.20
Ethylbenzene	37.92	Arsenic, PM	3.13E-04	1,2-Dichloroethane	2.17
1,3-Butadiene	13.53	Naphthalene	2.29E-04	p-Dichlorobenzene	0.68
Naphthalene	6.75	POM, Group 2b	1.52E-04	Hexachloro-1,3-butadiene	0.26
Dichloromethane	2.55	Hexavalent Chromium	1.19E-04		
Tetrachloroethylene	2.22	POM, Group 5a	1.06E-04		
POM, Group 2b	1.73	Nickel, PM	9.73E-05		
POM, Group 2d	1.02	Ethylbenzene	9.48E-05		
Underhill, Vermont (Chittenden County) - UNVT					
Benzene	103.48	Formaldehyde	8.77E-04	Carbon Tetrachloride	3.76
Formaldehyde	67.43	Benzene	8.07E-04	Benzene	2.86
Acetaldehyde	37.96	1,3-Butadiene	4.06E-04	1,2-Dichloroethane	1.84
Ethylbenzene	37.92	Arsenic, PM	3.13E-04	Arsenic	1.22
1,3-Butadiene	13.53	Naphthalene	2.29E-04	1,3-Butadiene	0.19
Naphthalene	6.75	POM, Group 2b	1.52E-04		
Dichloromethane	2.55	Hexavalent Chromium	1.19E-04		
Tetrachloroethylene	2.22	POM, Group 5a	1.06E-04		
POM, Group 2b	1.73	Nickel, PM	9.73E-05		
POM, Group 2d	1.02	Ethylbenzene	9.48E-05		

Table 27-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Vermont Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Rutland, Vermont (Rutland County) - RUVT					
Benzene	48.90	Benzene	3.81E-04	Benzene	6.29
Formaldehyde	25.16	Formaldehyde	3.27E-04	Carbon Tetrachloride	3.80
Acetaldehyde	17.87	1,3-Butadiene	1.64E-04	1,3-Butadiene	3.33
Ethylbenzene	14.81	Naphthalene	1.13E-04	1,2-Dichloroethane	1.99
1,3-Butadiene	5.47	POM, Group 2b	7.01E-05	Ethylbenzene	0.67
Naphthalene	3.32	POM, Group 5a	6.22E-05		
POM, Group 2b	0.80	Arsenic, PM	4.26E-05		
POM, Group 2d	0.45	POM, Group 2d	3.94E-05		
Tetrachloroethylene	0.38	Acetaldehyde	3.93E-05		
Trichloroethylene	0.30	Ethylbenzene	3.70E-05		

Table 27-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Vermont Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Burlington, Vermont (Chittenden County) - BURVT					
Toluene	250.92	Acrolein	546,915.43	1,3-Butadiene	0.04
Xylenes	174.70	Chlorine	12,098.33	Benzene	0.02
Hexane	106.23	Manganese, PM	9,934.56	Carbon Tetrachloride	0.01
Benzene	103.48	Formaldehyde	6,880.35	Hexachloro-1,3-butadiene	<0.01
Methanol	90.73	1,3-Butadiene	6,767.01	p-Dichlorobenzene	<0.01
Formaldehyde	67.43	Arsenic, PM	4,859.91	1,2-Dichloroethane	<0.01
Acetaldehyde	37.96	Acetaldehyde	4,218.14		
Ethylbenzene	37.92	Benzene	3,449.29		
Hydrochloric acid	35.41	Cadmium, PM	2,474.68		
Ethylene glycol	31.16	Nickel, PM	2,252.18		
Underhill, Vermont (Chittenden County) - UNVT					
Toluene	250.92	Acrolein	546,915.43	Arsenic	0.02
Xylenes	174.70	Chlorine	12,098.33	Benzene	0.01
Hexane	106.23	Manganese, PM	9,934.56	Carbon Tetrachloride	0.01
Benzene	103.48	Formaldehyde	6,880.35	1,3-Butadiene	<0.01
Methanol	90.73	1,3-Butadiene	6,767.01	1,2-Dichloroethane	<0.01
Formaldehyde	67.43	Arsenic, PM	4,859.91		
Acetaldehyde	37.96	Acetaldehyde	4,218.14		
Ethylbenzene	37.92	Benzene	3,449.29		
Hydrochloric acid	35.41	Cadmium, PM	2,474.68		
Ethylene glycol	31.16	Nickel, PM	2,252.18		

Table 27-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Vermont Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Rutland, Vermont (Rutland County) - RUVT					
Toluene	107.88	Acrolein	80,780.90	1,3-Butadiene	0.06
Xylenes	60.02	1,3-Butadiene	2,734.26	Benzene	0.03
Benzene	48.90	Formaldehyde	2,567.26	Carbon Tetrachloride	0.01
Hexane	39.43	Acetaldehyde	1,985.32	Ethylbenzene	<0.01
Methanol	35.40	Benzene	1,630.13	1,2-Dichloroethane	<0.01
Formaldehyde	25.16	Naphthalene	1,107.67		
Acetaldehyde	17.87	Arsenic, PM	660.46		
Ethylbenzene	14.81	Xylenes	600.20		
Ethylene glycol	12.37	Lead, PM	572.30		
Methyl isobutyl ketone	5.54	Cadmium, PM	518.83		

Observations from Table 27-7 include the following:

- Benzene, formaldehyde, and acetaldehyde are the highest emitted pollutants with cancer UREs in both Chittenden and Rutland Counties, although the emissions in Chittenden County were nearly twice those in Rutland County.
- Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for both counties, although not necessarily in that order.
- Six of the highest emitted pollutants also have the highest toxicity-weighted emissions for Chittenden County while eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Rutland County.
- Benzene is at or near the top of emissions-based lists for both counties as well as at or near the top of each site's cancer risk approximations. The cancer risk approximation for carbon tetrachloride is also among the highest for all three sites, but this pollutant appears on neither emissions-based list for either county. 1,3-Butadiene is another pollutant for which a cancer risk approximation could be calculated for all three sites and appears on both emissions-based lists. Ethylbenzene also appears on both emissions-based lists for Chittenden and Rutland Counties but is only a pollutant of interest for RUVT.
- Arsenic has the fourth highest cancer risk approximation for UNVT and ranks fourth for its toxicity-weighted emissions, but is not one of the highest emitted in Chittenden County.
- Naphthalene ranks fifth for its toxicity-weighted emissions and sixth for its total emissions for Chittenden County. Naphthalene failed screens for UNVT but was not identified as a pollutant of interest for this site.
- Several POM Groups appear on the emissions-based lists for Chittenden and Rutland Counties. Several of the PAHs sampled for at UNVT are included in various POM Groups. Benzo(a)pyrene is part of POM, Group 5a; POM, Group 2b includes acenaphthylene, fluoranthene, and perylene; and POM, Group 2d includes anthracene, phenanthrene, and pyrene. None of the pollutants sampled for at UNVT and included in these POM groups failed screens.
- Hexvalent chromium ranks seventh for its toxicity-weighted emissions for Chittenden County. Although this pollutant was sampled for at UNVT, none of the concentrations of this pollutant failed screens.

Observations from Table 27-8 include the following:

- Toluene and xylenes are the highest emitted pollutants with noncancer RfCs in both Chittenden and Rutland Counties, although the emissions in Chittenden County were greater than those in Rutland County.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both Chittenden and Rutland Counties. Although acrolein was sampled for at all three sites, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.
- Three of the highest emitted pollutants for Chittenden County also have the highest toxicity-weighted emissions while four of the highest emitted pollutants for Rutland County also have the highest toxicity-weighted emissions.
- Although very low, 1,3-butadiene and benzene have the highest noncancer hazard approximations for BURVT and RUVT. Benzene appears on both emissions-based lists for both counties. Although 1,3-butadiene also appears among the pollutants with the highest toxicity-weighted emissions for both counties, is not among the highest emitted in either county (of the pollutants with noncancer RfCs).
- Although very low, arsenic has the highest noncancer hazard approximation for UNVT. While this pollutant ranks fifth among the toxicity-weighted emissions for Chittenden County, it is not among the highest emitted. Four of the metals sampled for at UNVT appear among the pollutants with the highest toxicity-weighted emissions but none are not among the highest emitted.

27.6 Summary of the 2013 Monitoring Data for the Vermont Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *A total of eight pollutants failed screens for BURVT; six pollutants failed screens for RUVT; and nine pollutants failed screens for UNVT.*
- ❖ *None of the pollutants of interest for the Vermont sites had annual average concentrations greater than 1 µg/m³.*
- ❖ *The detection rate of 1,2-dichloroethane has increased significantly at each of the Vermont sites in the recent years.*
- ❖ *The annual average concentrations for several of UNVT's pollutants of interest were the lowest annual averages among NMP sites sampling those pollutants.*

28.0 Site in Virginia

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Virginia, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

28.1 Site Characterization

This section characterizes the Virginia monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The RIVA monitoring site is located just outside the Richmond, Virginia city limits in East Highland Park. Figure 28-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 28-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 28-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 28-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 28-1. East Highland Park, Virginia (RIVA) Monitoring Site

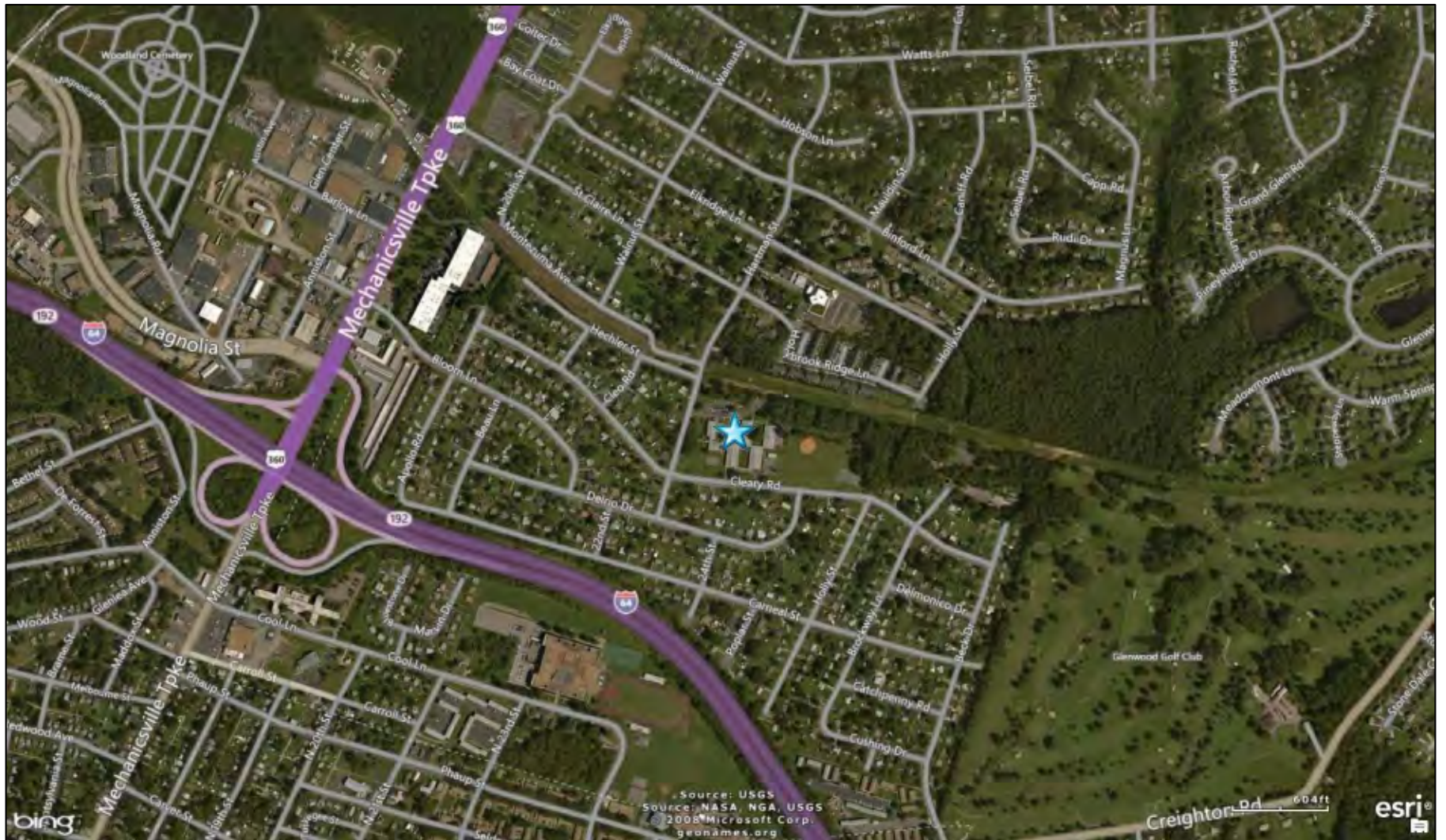


Figure 28-2. NEI Point Sources Located Within 10 Miles of RIVA

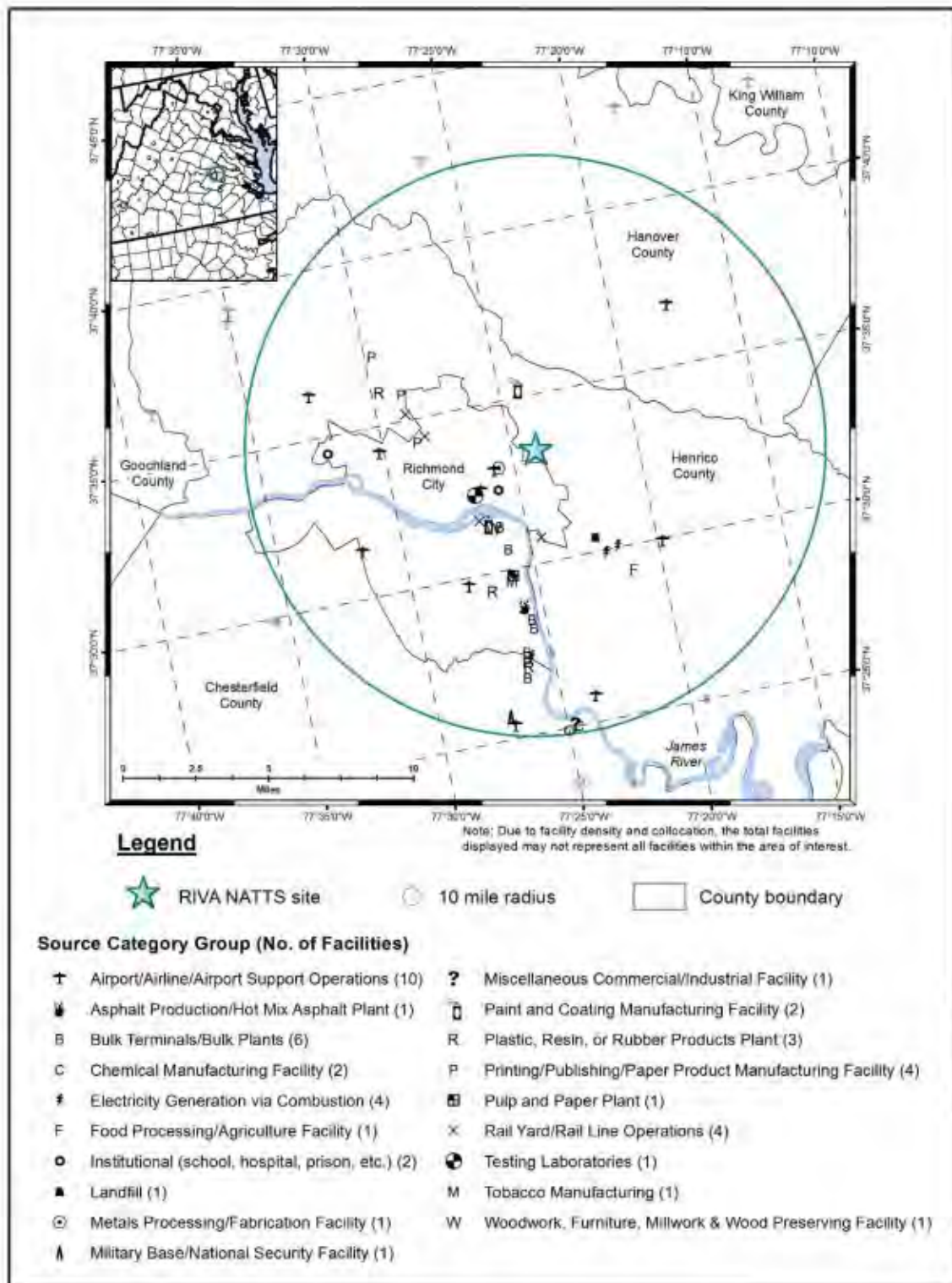


Table 28-1. Geographical Information for the Virginia Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>RIVA</i>	51-087-0014	East Highland Park	Henrico	Richmond, VA	37.55652, -77.40027	Residential	Suburban	Lead TSP, CO, SO ₂ , NO _y , NO, NO ₂ , NO _x , VOCs, Carbonyl compounds, O ₃ , Meteorological parameters, PAMS/NMOC, PM ₁₀ , PM ₁₀ Metals, PM Coarse, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for this site (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The RIVA monitoring site is located just northeast of the capital city of Richmond, in east-central Virginia. The site is located at the MathScience Innovation Center in a residential area about one-quarter mile from I-64. The I-64 interchange with Mechanicsville Turnpike (US-360) is one-half mile west of the site, as shown in Figure 28-1. Beyond the residential areas surrounding the school property are a golf course to the southeast, a high school to the south (on the south side of I-64), and commercial areas to the west. As Figure 28-2 shows, RIVA is located near several point sources, most of which are located to the south and southwest of the site and within the city of Richmond. The sources closest to RIVA are a metals processing and fabrication facility and a heliport at the Medical College of Virginia. The source categories with the greatest number of emissions sources within 10 miles of RIVA are the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; bulk terminals and bulk plants; printing, publishing, and paper product manufacturers; rail yard and rail line operations; and facilities generating electricity via combustion.

Table 28-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Virginia monitoring site. Table 28-2 includes both county-level population and vehicle registration information. Table 28-2 also contains traffic volume information for RIVA as well as the location for which the traffic volume was obtained. Additionally, Table 28-2 presents the county-level daily VMT for Henrico County.

Table 28-2. Population, Motor Vehicle, and Traffic Information for the Virginia Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
<i>RIVA</i>	Henrico	318,611	350,000	72,000	I-64 at Mechanicsville Turnpike	8,366,945

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2013 data (Henrico County, 2014)

³AADT reflects 2012 data (VA DOT, 2012)

⁴County-level VMT reflects 2013 data (VA DOT, 2014)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 28-2 include the following:

- RIVA's county-level population is in the middle third of the range compared to other counties with NMP sites, as is its county-level vehicle ownership.

- The traffic volume experienced near RIVA is in the top third of the range compared to other NMP monitoring sites, ranking 18th. The traffic volume provided is for I-64 at US-360 (Mechanicsville Turnpike).
- The daily VMT for Henrico County is also in the middle of the range compared to other counties with NMP sites.

28.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Virginia on sample days, as well as over the course of the year.

28.2.1 Climate Summary

The city of Richmond is located in east-central Virginia, east of the Blue Ridge Mountains and west of the Chesapeake Bay and Atlantic Ocean. The James River flows through the west, center, and south parts of town. Richmond has a modified continental climate. Winters tend to be mild, as the mountains can act as a barrier to cold air and the proximity to the Atlantic Ocean prevents temperatures from dropping too low. Summers are warm and humid, also due to these influences. Precipitation is well distributed throughout the year, with greater than 3 inches typical during most months of the year. A northerly wind is most common during the fall and winter months while southerly winds prevail during the warmest months of the year (Wood, 2004).

28.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Virginia monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station is located at Richmond International Airport (WBAN 13740). Additional information about the Richmond International Airport weather station, such as the distance between the site and the weather station, is provided in Table 28-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 28-3. Average Meteorological Conditions near the Virginia Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
East Highland Park, Virginia - RIVA									
Richmond International Airport 13740 (37.51, -77.32)	5.7 miles	Sample Days (63)	69.0 ± 4.3	59.4 ± 4.1	47.1 ± 4.9	53.3 ± 4.0	66.9 ± 3.4	1019.5 ± 1.6	6.2 ± 0.6
	129° (SE)	2013	68.4 ± 1.7	59.0 ± 1.7	47.0 ± 1.9	53.1 ± 1.6	67.6 ± 1.5	1019.0 ± 0.7	6.2 ± 0.3

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 28-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 28-3 is the 95 percent confidence interval for each parameter. As shown in Table 28-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year.

28.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at Richmond International Airport near RIVA were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

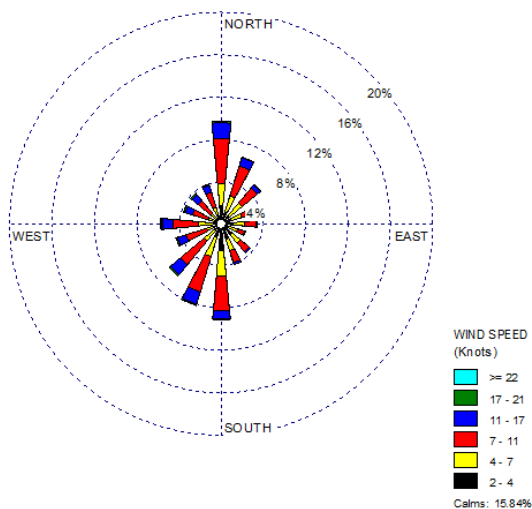
Figure 28-3 presents a map showing the distance between the weather station and RIVA, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 28-3 also presents three different wind roses for the RIVA monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 28-3. Wind Roses for the Richmond International Airport Weather Station near RIVA

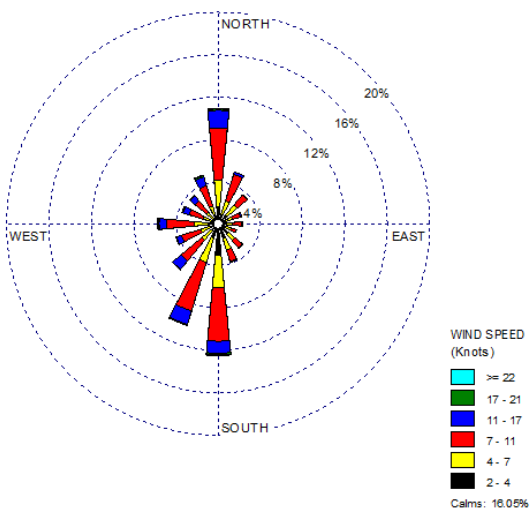
Location of RIVA and Weather Station



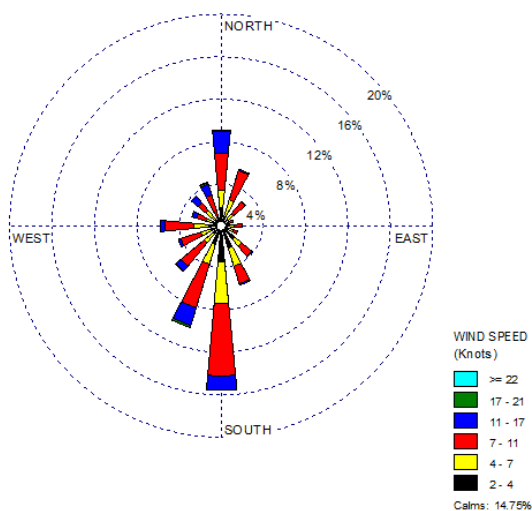
2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 28-3 for RIVA include the following:

- The Richmond International Airport weather station is located 5.7 miles east-southeast of RIVA.
- The historical wind rose shows that the most commonly observed wind direction is north, although winds from the south are a close second. Winds from the north-northeast, south-southwest, and southwest were also frequently observed. Winds from the southeast and northwest quadrants were observed less frequently. Calm winds (those less than or equal to 2 knots) were observed for approximately 16 percent of the hourly wind measurements.
- The 2013 wind rose resembles the historical wind rose in some ways but exhibits differences as well. Northerly, southerly, and south-southwesterly winds were still prominent in 2013 but accounted for a higher percentage of observations while fewer southwesterly to westerly and north-northeasterly to northeasterly winds were observed. Southerly winds were observed slightly more often than northerly winds in 2013 (while the reverse is true for the historical wind rose).
- Southerly winds account for the greatest number of wind observations on sample days near RIVA (approximately 16 percent), followed by south-southwesterly winds (roughly 10 percent), both of which are greater than the number of northerly wind observations (9 percent). The calm rate on sample days is just less than 15 percent.

28.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the Virginia monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 28-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 28-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. PAHs and hexavalent chromium were sampled for year-round at RIVA. RIVA is one of two NATTS sites to continue sampling hexavalent chromium beyond the summer of 2013.

Table 28-4. Risk-Based Screening Results for the Virginia Monitoring Site

Pollutant	Screening Value (µg/m ³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
East Highland Park, Virginia - RIVA						
Naphthalene	0.029	56	58	96.55	100.00	100.00
Total		56	58	96.55		

Observations from Table 28-4 include the following:

- Naphthalene is the only pollutant sampled for at RIVA to fail screens.
- Naphthalene was detected in all 58 valid PAH samples collected at RIVA.
- Naphthalene failed greater than 96 percent of its screens, with 56 of 58 measured detections of naphthalene failing screens.

28.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Virginia monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at RIVA are provided in Appendices M and O.

28.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for RIVA, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must

have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Virginia monitoring site are presented in Table 28-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 28-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Virginia Monitoring Site

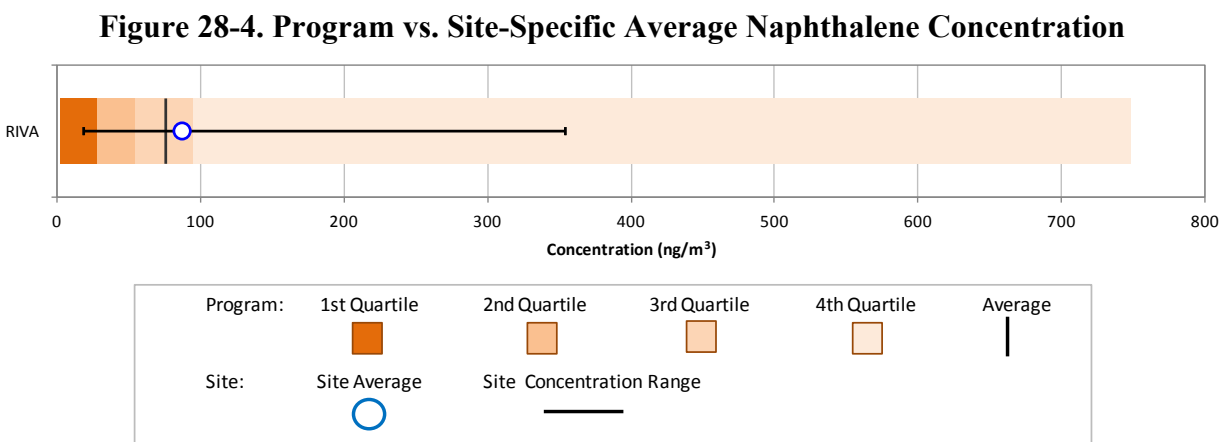
Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
East Highland Park, Virginia - RIVA						
Naphthalene	58/58	98.06 ± 42.46	75.73 ± 23.70	90.85 ± 19.71	81.95 ± 24.09	86.87 ± 13.95

Observations for RIVA from Table 28-5 include the following:

- Concentrations of naphthalene measured at RIVA range from 18.0 ng/m³ to 354 ng/m³.
- The first quarter average concentration of naphthalene exhibits the most variability, as indicated by the confidence interval. The maximum concentration was measured at RIVA on January 10, 2013 (354 ng/m³). Four additional naphthalene concentrations greater than 100 ng/m³ were also measured during the first quarter of 2013. However, the 16 concentrations of naphthalene greater than 100 ng/m³ were measured at RIVA on sample days spread across the year: five were measured during the first quarter, three were measured during the second quarter, three were measured during the third quarter, and five were measured during the fourth quarter.
- Compared to other NMP sites sampling PAHs, RIVA has the eighth highest annual average concentration of naphthalene, as shown in Table 4-11 of Section 4.

28.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, a box plot was created for the pollutant shaded in gray in Table 28-4 for RIVA. Figure 28-4 overlays the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.4.3.1.



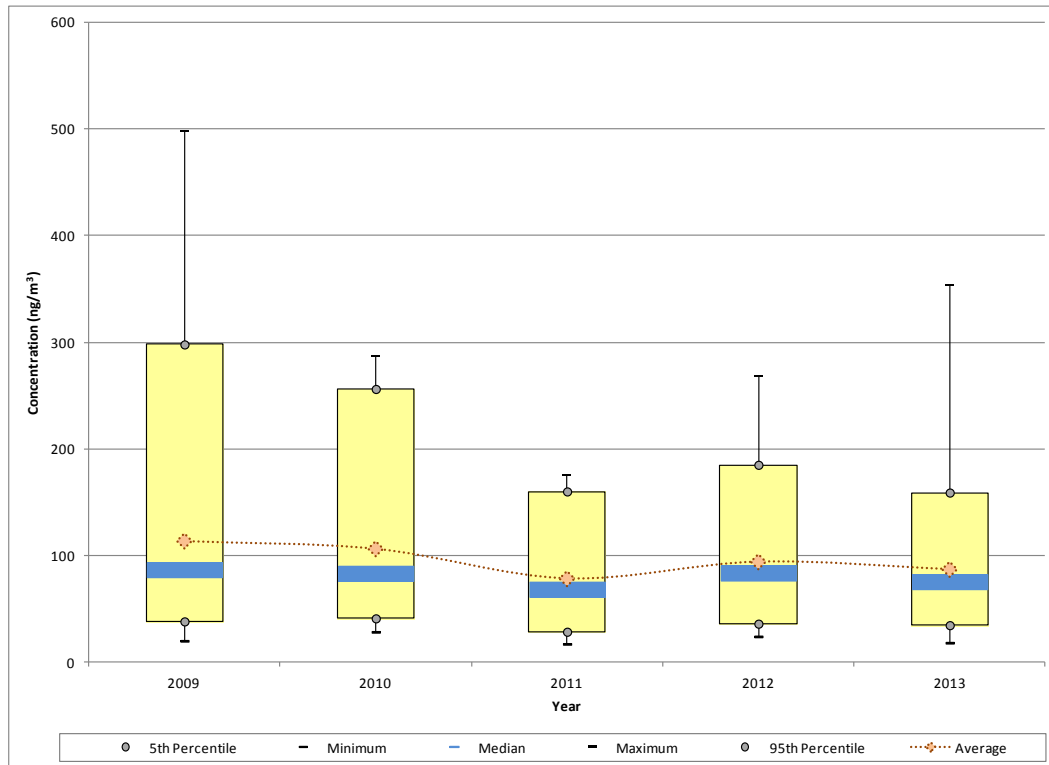
Observations from Figure 28-4 include the following:

- Figure 28-4 shows that the annual average concentration of naphthalene for RIVA is just greater than the program-level average concentration (75.26 ng/m³). The maximum naphthalene concentration measured at RIVA is roughly half the program-level maximum concentration. There were no non-detects of naphthalene measured at RIVA or across the program.

28.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. RIVA began sampling PAHs under the NMP in October 2008. Thus, Figure 28-5 presents the 1-year statistical metrics for the pollutant of interest for RIVA. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

Figure 28-5. Yearly Statistical Metrics for Naphthalene Concentrations Measured at RIVA



Observations from Figure 28-5 for naphthalene measurements collected at PRRI include the following:

- RIVA began sampling PAHs under the NMP in October 2008. Because less than 6 months of data are available for 2008, Figure 28-5 begins with 2009.
- The three naphthalene concentrations greater than 400 ng/m^3 were measured at RIVA during the fall of 2009. The next highest concentration was measured in 2013 (354 ng/m^3).
- Most of the statistical parameters exhibit a decreasing trend through 2011, with the most significant change occurring between 2010 and 2011. All of the statistical parameters are at a minimum in 2011 except the 95th percentile, which is just greater than the 95th percentile for 2013.
- With the exception of the maximum concentration, the statistical parameters calculated for 2013 are similar to those calculated for 2011.

28.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the RIVA monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

28.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for RIVA and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 28-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 28-6. Risk Approximations for the Virginia Monitoring Site

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
East Highland Park, Virginia - RIVA						
Naphthalene	0.000034	0.003	58/58	86.87 ± 13.95	2.95	0.03

Observations for RIVA from Table 28-6 include the following:

- The annual average concentration of naphthalene for RIVA is $86.87 \pm 13.95 \text{ ng}/\text{m}^3$.
- The cancer risk approximation for naphthalene based on RIVA's annual average concentration is 2.95 in-a-million.
- The noncancer hazard approximation for naphthalene is considerably less than 1.0 (0.03), indicating that no adverse noncancer health effects are expected from this individual pollutant.

28.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 28-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 28-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 28-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for RIVA, as presented in Table 28-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 28-7. Table 28-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual average concentrations to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 28.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Table 28-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Virginia Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
East Highland Park, Virginia (Henrico County) - RIVA					
Benzene	102.27	Formaldehyde	1.12E-03	Naphthalene	2.95
Formaldehyde	86.37	Benzene	7.98E-04		
Acetaldehyde	50.16	1,3-Butadiene	5.48E-04		
Ethylbenzene	48.29	Naphthalene	2.84E-04		
1,3-Butadiene	18.27	POM, Group 2b	2.22E-04		
Tetrachloroethylene	17.17	POM, Group 2d	1.26E-04		
Naphthalene	8.35	Ethylbenzene	1.21E-04		
POM, Group 2b	2.52	Acetaldehyde	1.10E-04		
POM, Group 2d	1.43	POM, Group 5a	8.51E-05		
Trichloroethylene	0.85	Arsenic, PM	6.88E-05		

Table 28-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Virginia Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
East Highland Park, Virginia (Henrico County) - RIVA					
Toluene	542.35	Acrolein	276,867.54	Naphthalene	0.03
Hexane	196.44	1,3-Butadiene	9,132.57		
Xylenes	193.08	Formaldehyde	8,812.86		
Methanol	181.20	Acetaldehyde	5,572.79		
Benzene	102.27	Benzene	3,408.91		
Formaldehyde	86.37	Naphthalene	2,783.60		
Ethylene glycol	62.63	Xylenes	1,930.83		
Acetaldehyde	50.16	Arsenic, PM	1,067.34		
Ethylbenzene	48.29	Lead, PM	808.19		
Methyl isobutyl ketone	24.42	Propionaldehyde	556.24		

Observations from Table 28-7 include the following:

- Benzene, formaldehyde, and acetaldehyde are the highest emitted pollutants with cancer UREs in Henrico County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, benzene, and 1,3-butadiene.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Henrico County.
- Naphthalene, the only pollutant of interest for RIVA, has the seventh highest emissions and the fourth highest toxicity-weighted emissions for Henrico County.
- POM, Group 2b is the eighth highest emitted “pollutant” in Henrico County and ranks fifth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at RIVA, including fluorene, perylene, and acenaphthene. POM, Group 2d also appears on both emissions-based lists for Henrico County and includes anthracene, phenanthrene, and pyrene. POM, Group 5a includes benzo(a)pyrene and ranked ninth for toxicity-weighted emissions but is not among the highest emitted. None of the PAHs sampled for at RIVA included in POM, Groups 2b, 2d, or 5a failed screens.

Observations from Table 28-8 include the following:

- Toluene, hexane, and xylenes are the highest emitted pollutants with noncancer RfCs in Henrico County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, 1,3-butadiene, and formaldehyde.
- Four of the highest emitted pollutants in Henrico County also have the highest toxicity-weighted emissions.
- Naphthalene has the sixth highest toxicity-weighted emissions for Henrico County but is not among the highest emitted pollutants with a noncancer toxicity factor in Henrico County.

28.6 Summary of the 2013 Monitoring Data for RIVA

Results from several of the data treatments described in this section include the following:

- ❖ *Naphthalene was the only pollutant sampled for at RIVA whose concentrations failed screens, making naphthalene RIVA’s only pollutant of interest.*
- ❖ *RIVA has the eighth highest annual average concentration of naphthalene among NMP sites sampling PAHs.*

29.0 Site in Washington

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Washington, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

29.1 Site Characterization

This section characterizes the Washington monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The NATTS site in Washington is located in Seattle. Figure 29-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 29-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 29-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Table 29-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 29-1. Seattle, Washington (SEWA) Monitoring Site

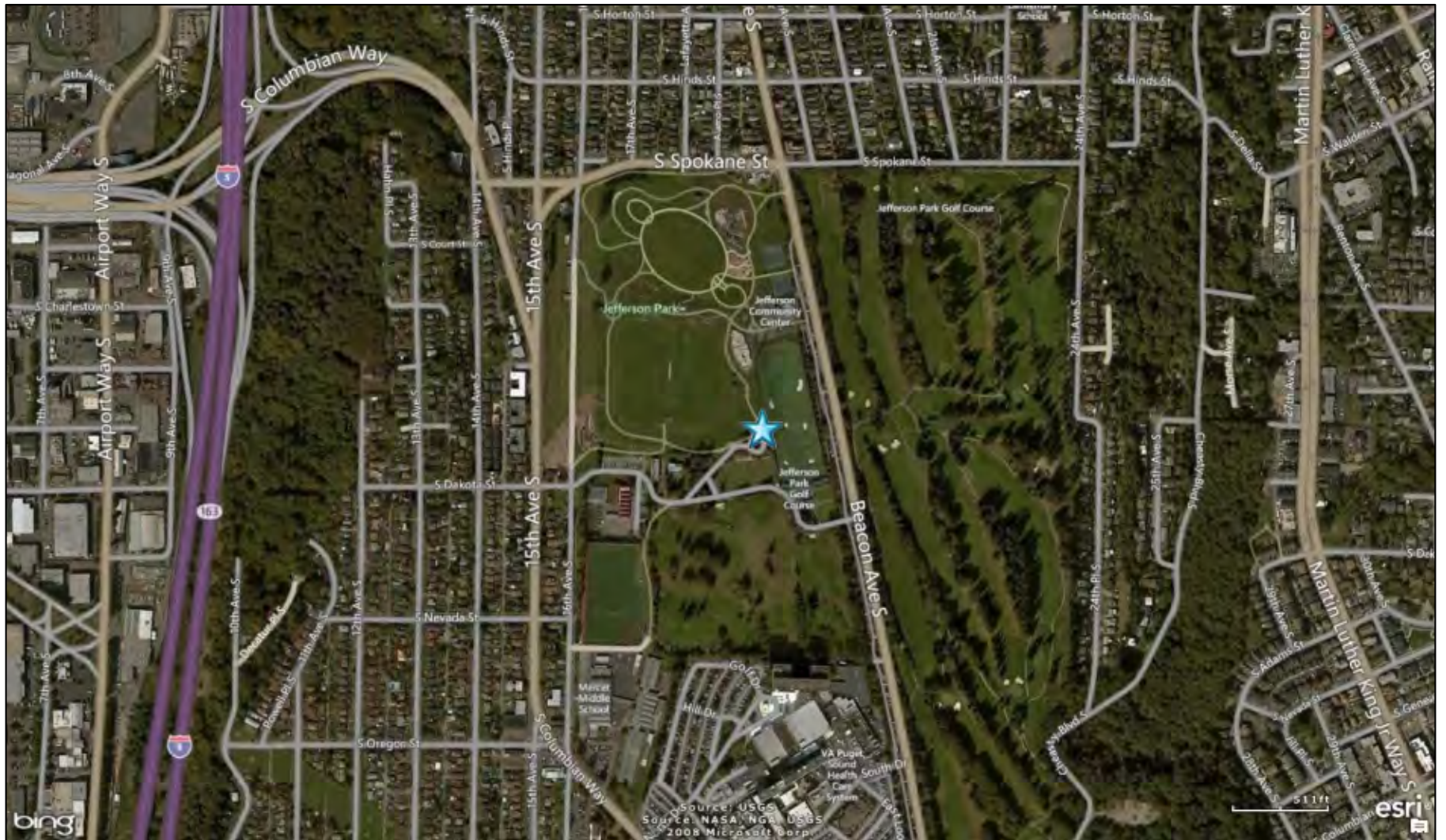


Figure 29-2. NEI Point Sources Located Within 10 Miles of SEWA

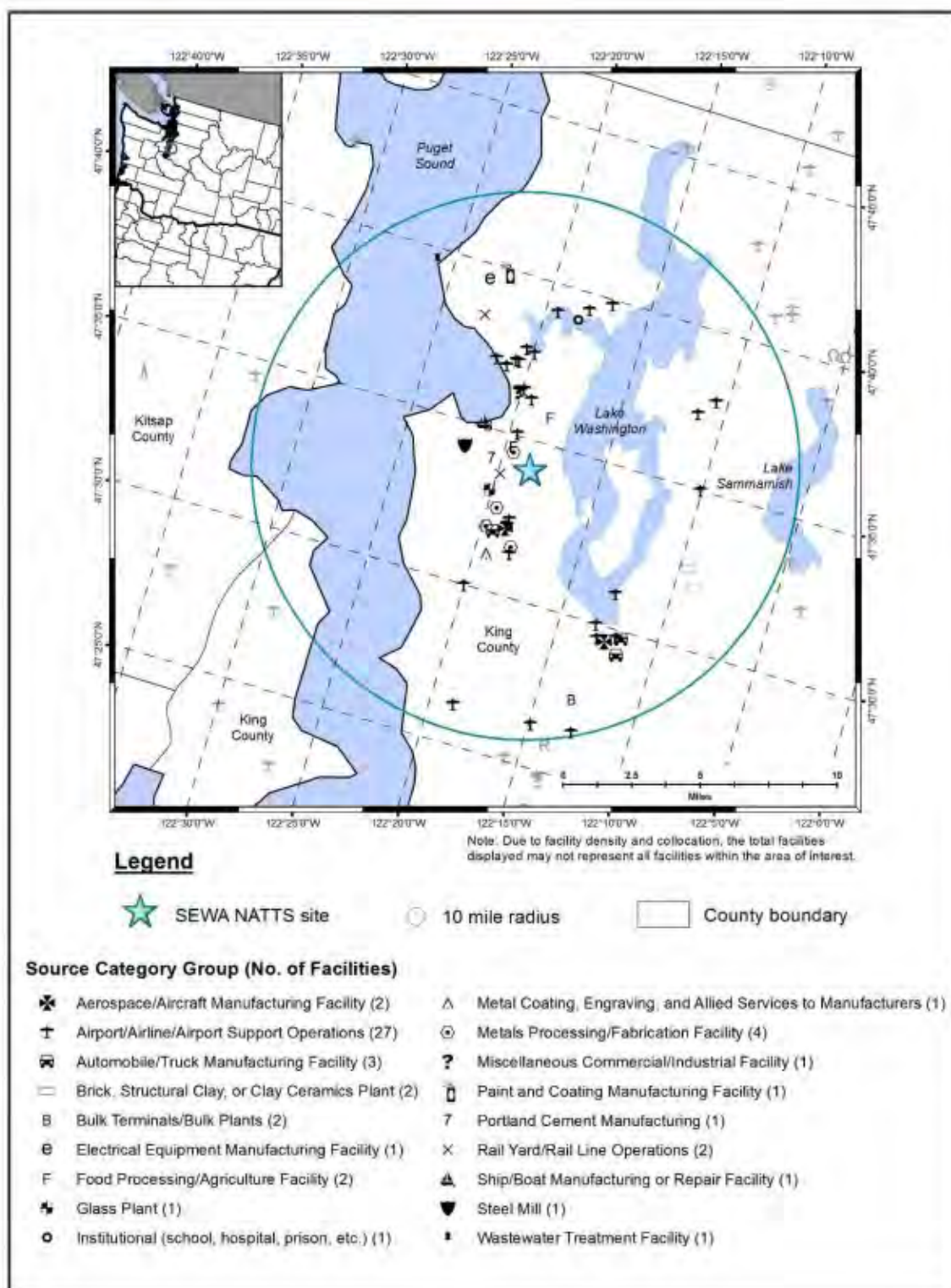


Table 29-1. Geographical Information for the Washington Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
<i>SEWA</i>	53-033-0080	Seattle	King	Seattle-Tacoma-Bellevue, WA	47.568236, -122.308628	Residential	Urban/City Center	Haze, CO, SO ₂ , NO _x , NO _y , NO, NO ₂ , O ₃ , Meteorological parameters, PM Coarse, PM ₁₀ , PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for SEWA (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The SEWA monitoring site is located in Seattle, at the southeast corner of the Beacon Hill Reservoir. With the north reservoir decommissioned and the south reservoir covered, the entire area is part of Jefferson Park (Seattle, 2015). The reservoir and park are separated from the Jefferson Park Golf Course to the east by Beacon Avenue, as shown in Figure 29-1. A middle school and a hospital can be seen to the south of the site in the bottom-center portion of Figure 29-1. The site is surrounded by residential neighborhoods to the west, north, and east. Interstate-5, which runs north-south through Seattle, is less than 1 mile to the west of SEWA and intersects with I-90 a couple of miles to the north of the site. The area to the west of I-5 is highly industrial while the area to the east is primarily residential. Although the emissions sources within 10 miles of the site are involved in a variety of industries, the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations, has the greatest number of sources. The closest point sources to SEWA are a metals processing and fabrication facility and a food processing facility, as shown in Figure 29-2.

Table 29-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Washington monitoring site. Table 29-2 includes both county-level population and vehicle registration information. Table 29-2 also contains traffic volume information for SEWA as well as the location for which the traffic volume was obtained. Additionally, Table 29-2 presents the county-level daily VMT for King County.

Table 29-2. Population, Motor Vehicle, and Traffic Information for the Washington Monitoring Site

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
SEWA	King	2,044,449	1,791,383	176,000	I-5 S at Spokane St Viaduct	23,266,320

¹County-level population estimate reflects 2013 data (Census Bureau, 2014)

²County-level vehicle registration reflects 2013 data (WS DOL, 2013)

³AADT reflects 2013 data (WS DOT, 2013)

⁴County-level VMT reflects 2013 data (WS DOT, 2013)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 29-2 include the following:

- King County has the sixth highest county-level population among counties with NMP sites.

- King County has the fifth highest county-level vehicle registration among counties with NMP sites.
- The traffic volume experienced near SEWA is the fifth highest compared to other NMP monitoring sites. The traffic estimate provided is for I-5 at the Spokane Street Viaduct.
- The daily VMT for King County is in the top third compared to other counties with NMP sites.

29.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Washington on sample days, as well as over the course of the year.

29.2.1 Climate Summary

The city of Seattle is located between Puget Sound and Lake Washington. The entire urban area is situated between the Olympic Mountains to the west and the Cascades to the east. The area experiences a mild climate as the mountains moderate storm systems that move into the Pacific Northwest and both the mountains and the sound shield the city from temperature extremes. Although the city is known for its cloudy, rainy conditions, actual precipitation totals tend to be comparable or less than many locations east of the Rocky Mountains. The majority of precipitation falls during the winter months, with monthly totals greater than 5 inches common between November and January while less than 2 inches is typical during the summer. Normal annual snowfall amounts are around 10 inches. Prevailing winds in the Seattle area are out of the south to south-southwest for much of the year (Wood, 2004; WRCC 2014).

29.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather station closest to the Washington monitoring site (NCDC, 2013), as described in Section 3.4.2. The closest weather station to SEWA is located at Boeing Field/King County International Airport (WBAN 24234). Additional information about this weather station, such as the distance between the site and the weather station, is provided in Table 29-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 29-3. Average Meteorological Conditions near the Washington Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Seattle, Washington - SEWA									
Boeing Field/ King County Intl Airport 24234 (47.53, -122.30)	2.7 miles 172° (S)	Sample Days (65)	61.1 ± 3.3	54.4 ± 2.7	43.7 ± 2.2	49.0 ± 2.2	69.8 ± 3.0	1019.5 ± 1.5	3.7 ± 0.5
		2013	61.0 ± 1.3	54.2 ± 1.1	43.4 ± 0.9	48.7 ± 0.9	69.3 ± 1.2	1019.3 ± 0.7	4.0 ± 0.2

¹Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

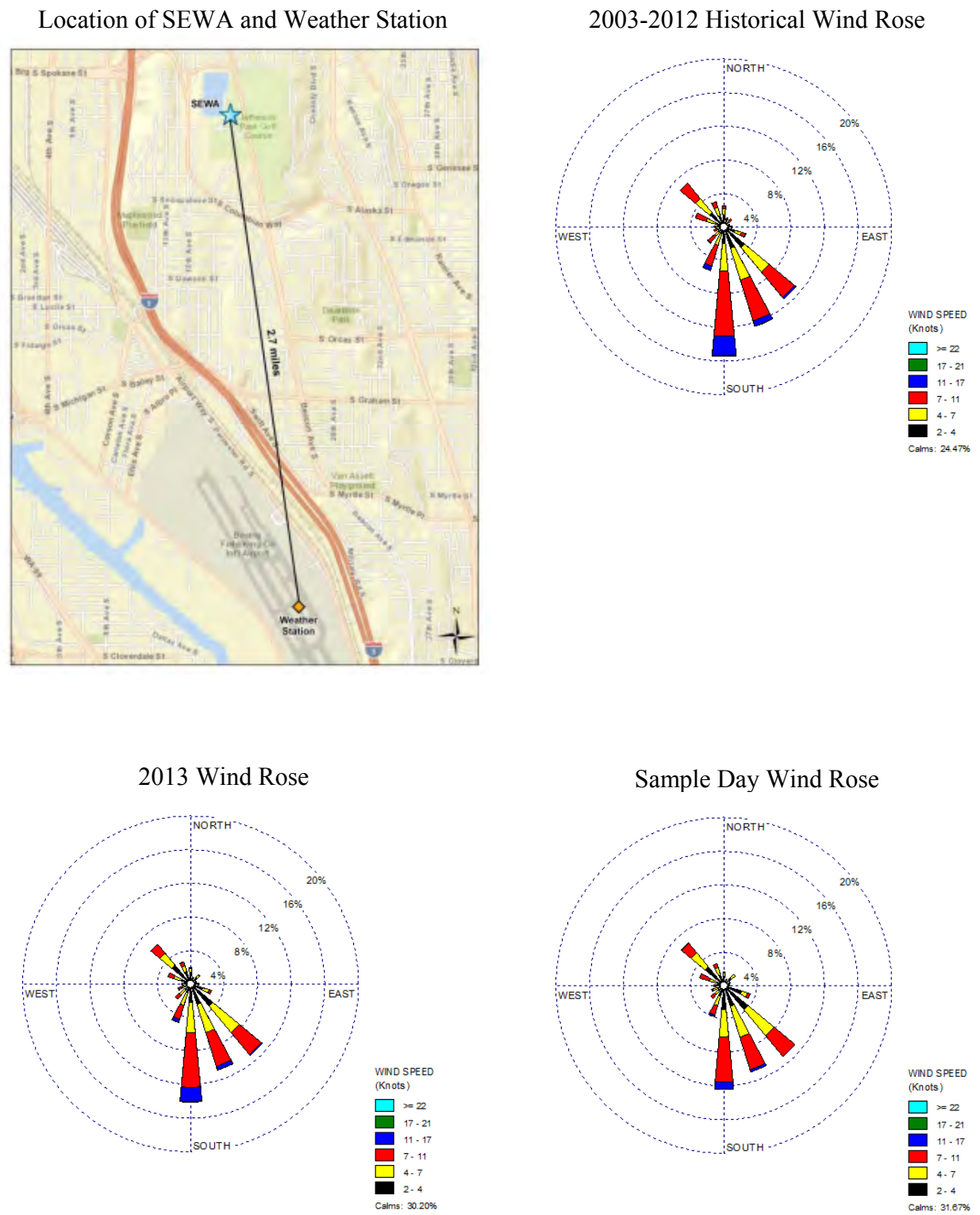
Table 29-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Also included in Table 29-3 is the 95 percent confidence interval for each parameter. As shown in Table 29-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year. The average sea level pressure for SEWA in 2013 in Table 29-3 is the highest among all NMP sites.

29.2.3 Wind Rose Comparison

Hourly surface wind data from the weather station at Boeing Field/King County International Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 29-3 presents a map showing the distance between the weather station and SEWA, which may be useful for identifying topographical influences that can affect the meteorological patterns experienced at this location. Figure 29-3 also presents three different wind roses for the SEWA monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind data for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 29-3. Wind Roses for the Boeing Field/King County International Airport Weather Station near SEWA



Observations from Figure 29-3 for SEWA include the following:

- The Boeing Field/King County Airport weather station is located less than 3 miles south of SEWA.
- The historical wind rose shows that southeasterly, south-southeasterly, and southerly winds were frequently observed, accounting for nearly 40 percent of observations. Winds from the northeast quadrant were rarely observed. Calm winds (those greater than or equal to 2 knots) account for 24 percent of wind observations near SEWA.
- The wind patterns shown on the 2013 wind rose are similar to the historical wind patterns, although the percentage of calm winds is higher (30 percent).
- The wind patterns shown on the sample day wind rose resemble the wind patterns in 2013, albeit with an even higher percentage of calm winds, with nearly one-third of observations less than 2 knots. This indicates that conditions on sample days were representative of those experienced over the entire year (and historically).

29.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for SEWA in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 29-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 29-4. It is important to note which pollutants were sampled for at the site when reviewing the results of this analysis. PM₁₀ metals, VOCs, PAHs, carbonyl compounds, and hexavalent chromium were sampled for at SEWA, although hexavalent chromium sampling was discontinued in June.

Observations from Table 29-4 for SEWA include the following:

- Fourteen pollutants failed at least one screen for SEWA; 56 percent of concentrations for these 14 pollutants were greater than their associated risk screening value (or failed screens).
- Nine pollutants contributed to 95 percent of failed screens for SEWA and therefore were identified as pollutants of interest for the site. These nine include two carbonyl compounds, four VOCs, two PM₁₀ metals, and one PAH.

- Benzene, carbon tetrachloride, and formaldehyde were detected in every valid VOC or carbonyl compound sample collected at SEWA and failed 100 percent of screens. 1,2-Dichloroethane also failed 100 percent of screens, but was not detected in every sample collected.

Table 29-4. Risk-Based Screening Results for the Washington Monitoring Site

Pollutant	Screening Value ($\mu\text{g}/\text{m}^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Seattle, Washington - SEWA						
Arsenic (PM_{10})	0.00023	57	60	95.00	12.78	12.78
Benzene	0.13	57	57	100.00	12.78	25.56
Carbon Tetrachloride	0.17	57	57	100.00	12.78	38.34
Formaldehyde	0.077	57	57	100.00	12.78	51.12
1,2-Dichloroethane	0.038	51	51	100.00	11.43	62.56
Naphthalene	0.029	48	57	84.21	10.76	73.32
1,3-Butadiene	0.03	47	49	95.92	10.54	83.86
Acetaldehyde	0.45	39	57	68.42	8.74	92.60
Nickel (PM_{10})	0.0021	14	60	23.33	3.14	95.74
Ethylbenzene	0.4	6	57	10.53	1.35	97.09
Cadmium (PM_{10})	0.00056	5	60	8.33	1.12	98.21
Acenaphthene	0.011	4	57	7.02	0.90	99.10
Fluorene	0.011	3	54	5.56	0.67	99.78
Manganese (PM_{10})	0.03	1	60	1.67	0.22	100.00
Total		446	793	56.24		

29.4 Concentrations

This section presents various concentration averages used to characterize air toxics pollution levels at the Washington monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Site-specific statistical summaries for all pollutants sampled for at SEWA are provided in Appendices J, L, M, N, and O.

29.4.1 2013 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for SEWA, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Washington monitoring site are presented in Table 29-5, where applicable. Note that concentrations of the PAHs and PM₁₀ metals are presented in ng/m³ for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 29-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Washington Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu\text{g}/\text{m}^3$)	2nd Quarter Average ($\mu\text{g}/\text{m}^3$)	3rd Quarter Average ($\mu\text{g}/\text{m}^3$)	4th Quarter Average ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Seattle, Washington - SEWA						
Acetaldehyde	57/57	0.46 ± 0.13	0.78 ± 0.29	0.85 ± 0.14	0.76 ± 0.28	0.72 ± 0.11
Benzene	57/57	0.80 ± 0.15	0.43 ± 0.09	0.35 ± 0.06	0.70 ± 0.21	0.56 ± 0.08
1,3-Butadiene	49/57	0.09 ± 0.03	0.04 ± 0.02	0.05 ± 0.01	0.12 ± 0.06	0.07 ± 0.02
Carbon Tetrachloride	57/57	0.64 ± 0.03	0.75 ± 0.07	0.70 ± 0.05	0.65 ± 0.03	0.69 ± 0.03
1,2-Dichloroethane	51/57	0.09 ± 0.01	0.09 ± 0.01	0.03 ± 0.01	0.07 ± 0.01	0.07 ± 0.01
Formaldehyde	57/57	0.42 ± 0.13	0.54 ± 0.18	0.68 ± 0.08	0.62 ± 0.22	0.57 ± 0.08
Arsenic (PM_{10}) ^a	60/60	0.96 ± 0.35	0.61 ± 0.16	0.65 ± 0.16	0.92 ± 0.33	0.79 ± 0.13
Naphthalene ^a	57/57	71.91 ± 26.73	61.84 ± 30.56	68.08 ± 17.93	81.30 ± 34.66	70.39 ± 13.09
Nickel (PM_{10}) ^a	60/60	1.58 ± 0.69	2.39 ± 1.49	2.21 ± 0.67	0.99 ± 0.27	1.78 ± 0.44

^a Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations from Table 29-5 include the following:

- The annual average concentrations for all of SEWA's pollutants of interest are less than $1.0 \mu\text{g}/\text{m}^3$. The pollutants with the highest annual average concentrations are acetaldehyde ($0.72 \pm 0.11 \mu\text{g}/\text{m}^3$), carbon tetrachloride ($0.69 \pm 0.03 \mu\text{g}/\text{m}^3$), formaldehyde ($0.57 \pm 0.08 \mu\text{g}/\text{m}^3$), and benzene ($0.56 \pm 0.08 \mu\text{g}/\text{m}^3$). These are similar to the annual average concentrations calculated for 2012.
- Even though acetaldehyde has the highest annual average concentration among SEWA's pollutants of interest, this annual average is one of the lowest among NMP sites sampling carbonyl compounds. SEWA's annual average concentration of formaldehyde is the lowest among all NMP sites. Few NMP sites have annual average concentrations of these two pollutants less than $1 \mu\text{g}/\text{m}^3$. Similar observations were made in previous NMP reports.
- Concentrations of acetaldehyde appear lowest during the first quarter of 2013. The three lowest concentrations of acetaldehyde measured at SEWA in 2013 were measured in February and March. No acetaldehyde concentrations greater than $1 \mu\text{g}/\text{m}^3$ were measured at SEWA during the first quarter of 2013; between three and six were measured in the remaining calendar quarters. A similar observation can be made for formaldehyde, although the difference is less dramatic. The minimum concentration of formaldehyde was measured at SEWA on the same day as the minimum acetaldehyde concentration. The fewest formaldehyde concentrations

greater than $0.5 \mu\text{g}/\text{m}^3$ were measured during the first quarter of 2013 (three) while the number ranges from six to 14 for the remaining calendar quarters.

- Concentrations of benzene and 1,3-butadiene appear higher during the colder months of the year based on the quarterly average concentrations shown in Table 29-5. A review of the data shows that all five benzene concentrations greater than $1 \mu\text{g}/\text{m}^3$ were measured in January, November, or December; further all but one of the 20 highest benzene concentrations measured at SEWA were measured in the first (12) or fourth (7) quarters of 2013. Conversely, the nine lowest concentrations of benzene were measured at SEWA during the second or third quarters of 2013. A similar observation can be made for 1,3-butadiene. All but one of the 10 1,3-butadiene concentrations greater than $0.1 \mu\text{g}/\text{m}^3$ were measured in January, November, or December and 14 of the 15 highest concentrations were measured in the first (6) or fourth (8) quarters of 2013.
- Concentrations of 1,2-dichloroethane measured during the third quarter appear significantly lower than those measured during the rest of the year, based on the quarterly average concentrations shown in Table 29-5. A review of the data shows that all six non-detects of this pollutant were measured in either August or September. In addition, none of the measurements from the third quarter are greater than the median concentration for the year ($0.07 \mu\text{g}/\text{m}^3$).
- The second and third quarter average concentrations of carbon tetrachloride are greater than the first or fourth quarter averages. A review of the data shows that the 11 concentrations greater than $0.75 \mu\text{g}/\text{m}^3$, including one greater than $1 \mu\text{g}/\text{m}^3$, were measured between May and August. SEWA is one of only five sites where carbon tetrachloride concentrations greater than $1 \mu\text{g}/\text{m}^3$ were measured.
- The quarterly average concentrations of naphthalene show that measurements of this pollutant are highly variable, as indicated by the confidence intervals. Concentrations measured at SEWA range from $7.73 \text{ ng}/\text{m}^3$ to $205 \text{ ng}/\text{m}^3$. Naphthalene concentrations greater than $100 \text{ ng}/\text{m}^3$ were measured during each calendar quarter, with two or three measured each quarter.
- Arsenic concentrations measured at SEWA during the first and fourth quarters of 2013 appear higher than those measured during the other calendar quarters and exhibit considerably more variability. A review of the data shows that arsenic concentrations measured at SEWA range from $0.13 \text{ ng}/\text{m}^3$ to $2.42 \text{ ng}/\text{m}^3$. Of the 15 arsenic concentrations greater than or equal to $1 \text{ ng}/\text{m}^3$ measured at SEWA, five were measured during the first quarter, two each were measured during the second or third quarters, and six were measured during the fourth quarter of 2013. The maximum arsenic concentrations measured during the first and fourth quarters are roughly twice the maximum concentrations measured during the second and third quarters of 2013.
- Concentrations of nickel measured at SEWA also appear highly variable, particularly for the second quarter. Concentrations of nickel measured at SEWA in 2013 range from $0.17 \text{ ng}/\text{m}^3$ to $9.75 \text{ ng}/\text{m}^3$; the maximum nickel concentration measured at this

site is among the higher nickel concentrations for the program. SEWA is one of the few NMP sites where multiple nickel concentrations greater than 5 ng/m³ were measured (ASKY-M and TOOK are the others). Three of the four nickel concentrations greater than 5 ng/m³ were measured at SEWA between April and June.

Tables 4-9 through 4-12 present the NMP sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for SEWA from those tables include the following:

- SEWA only appears in Table 4-9 for VOCs once; SEWA has the third highest annual average concentration of carbon tetrachloride among sites sampling VOCs. Note, however, that with the exceptions of the sites with two highest annual average concentrations of carbon tetrachloride, the annual averages shown in Table 4-9 span only 0.03 µg/m³. A similar observation was made in the 2012 NMP report.
- SEWA does not appear in Table 4-10 for carbonyl compounds. As indicated above, SEWA has one of the lowest annual average acetaldehyde concentration and the lowest annual average concentration of formaldehyde among NMP sites sampling these pollutants.
- Table 4-11 for the PAHs shows that SEWA has the ninth highest annual average concentration of acenaphthene. This pollutant failed screens for SEWA but was not identified as a site-specific pollutant of interest.
- As shown in Table 4-12, SEWA has the second highest annual average concentration of nickel among all sites sampling metals (PM₁₀), behind only ASKY-M. The same observation was made in the 2012 NMP report. SEWA had the highest annual average nickel concentration for the 2010 and 2011 NMP reports. SEWA also has the fourth highest annual average concentration of arsenic among NMP sites sampling PM₁₀ metals.

29.4.2 Concentration Comparison

In order to better illustrate how each site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 29-4 for SEWA. Figures 29-4 through 29-12 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations for each pollutant, as described in Section 3.4.3.1.

Figure 29-4. Program vs. Site-Specific Average Acetaldehyde Concentration

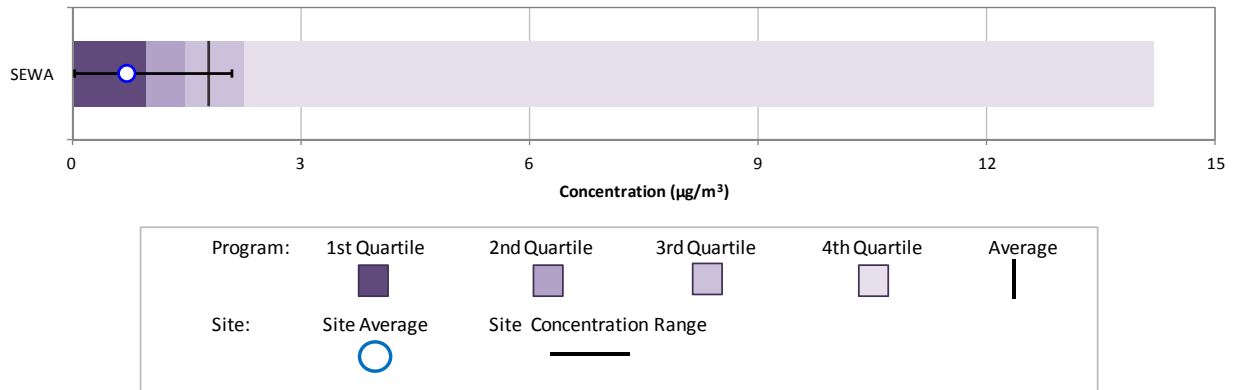


Figure 29-5. Program vs. Site-Specific Average Arsenic (PM₁₀) Concentration

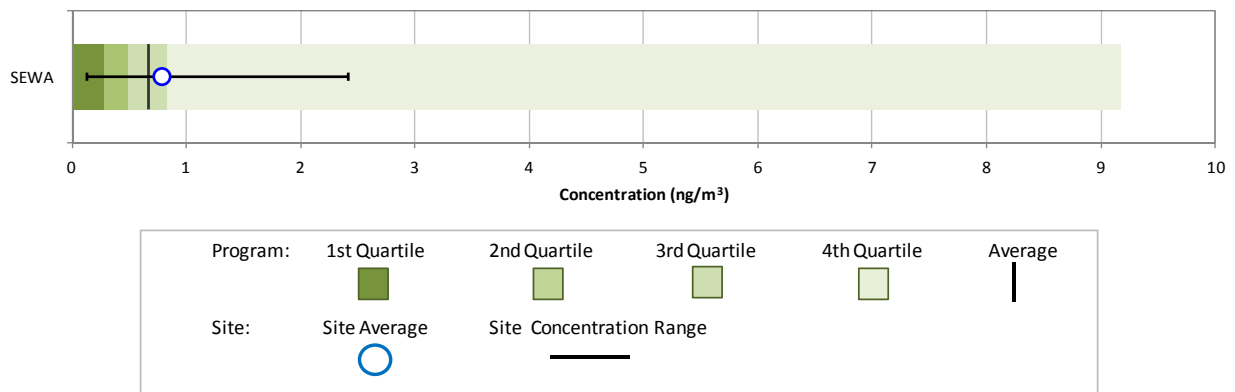


Figure 29-6. Program vs. Site-Specific Average Benzene Concentration

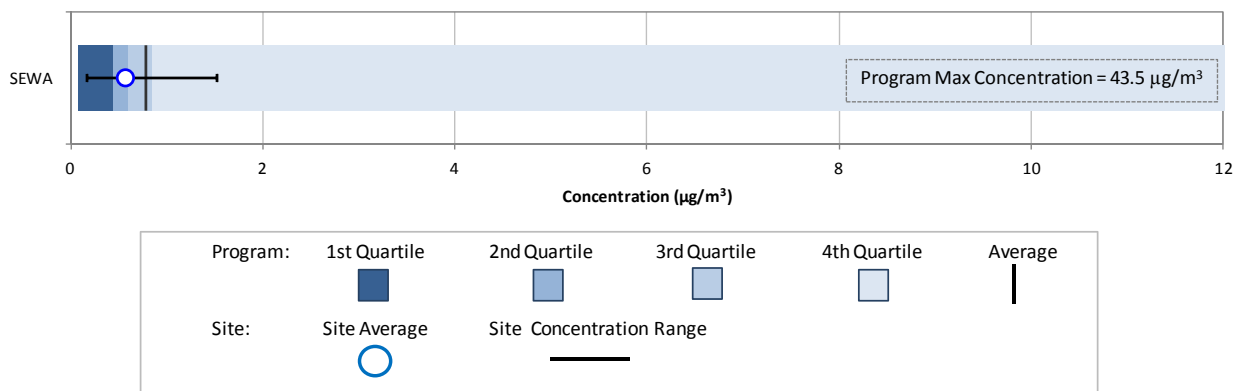


Figure 29-7. Program vs. Site-Specific Average 1,3-Butadiene Concentration

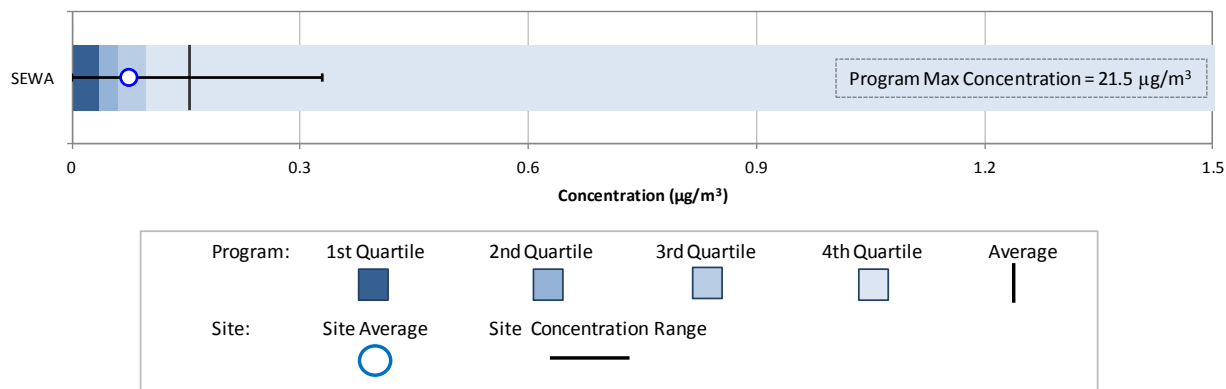


Figure 29-8. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

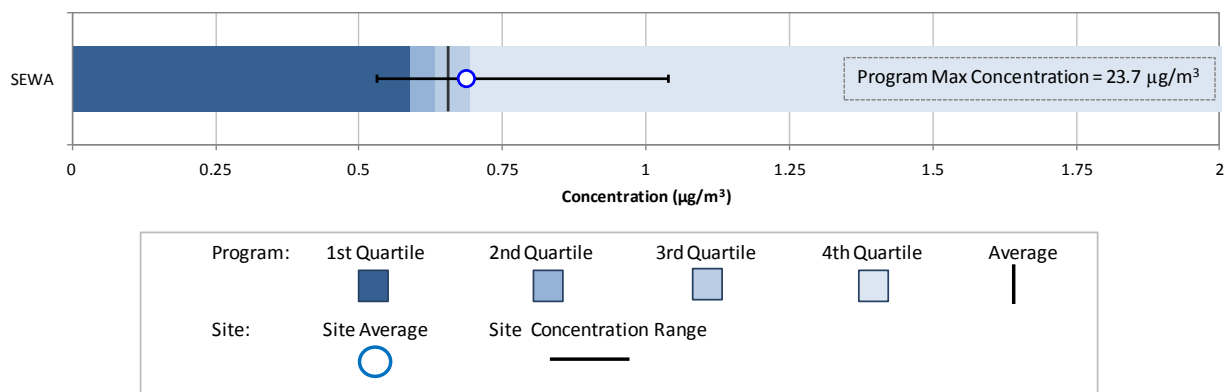


Figure 29-9. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

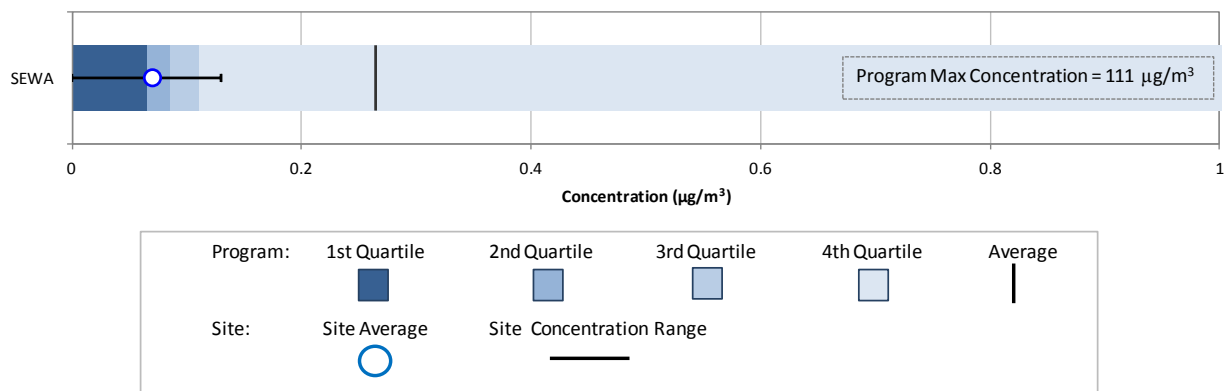


Figure 29-10. Program vs. Site-Specific Average Formaldehyde Concentration

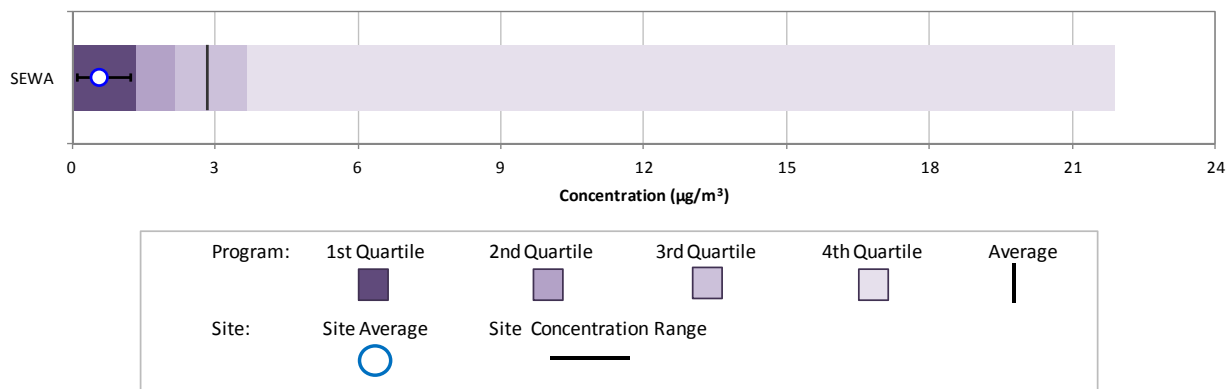


Figure 29-11. Program vs. Site-Specific Average Naphthalene Concentration

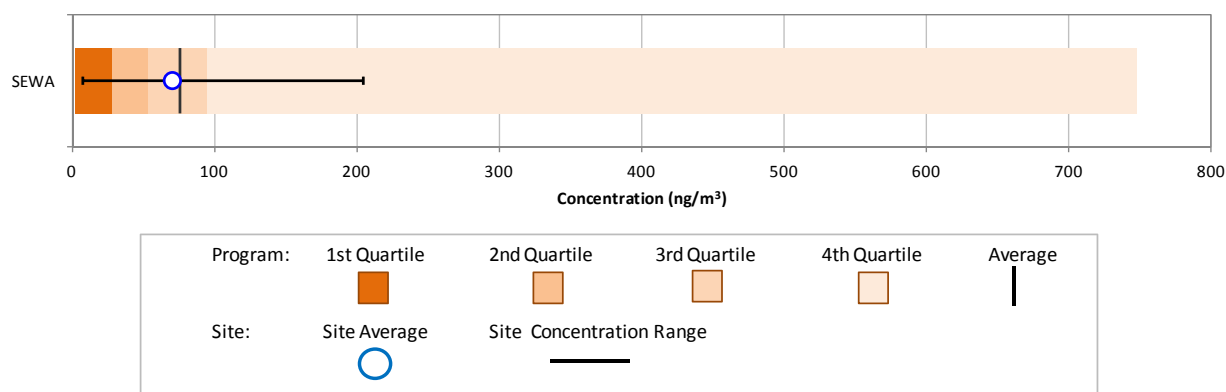
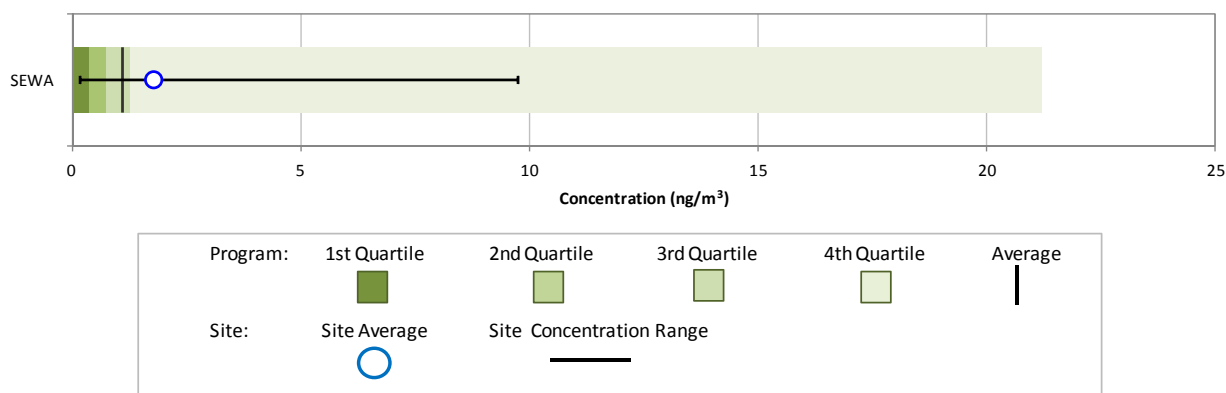


Figure 29-12. Program vs. Site-Specific Average Nickel (PM₁₀) Concentration



Observations from Figures 29-4 through 29-12 include the following:

- Figure 29-4 shows that the entire range of acetaldehyde concentrations measured at SEWA is less than the program-level third quartile. SEWA's annual average acetaldehyde concentration is considerably less than the program-level average concentration for acetaldehyde and less than the program-level first quartile (25th percentile). This site has one of the lowest annual average concentrations of acetaldehyde among NMP sites sampling carbonyl compounds.

- Figure 29-5 shows that SEWA's annual average arsenic (PM_{10}) concentration falls between the program-level average concentration and third quartile. The maximum arsenic concentration measured at SEWA is considerably less than the maximum concentration measured across the program. There were no non-detects of arsenic measured at SEWA, although there were a few measured across the program.
- Figure 29-6 presents the box plot for benzene. Note that the program-level maximum concentration ($43.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to $12 \mu\text{g}/\text{m}^3$. This figure shows that the annual average benzene concentration for SEWA is less than the program-level average concentration and similar to the program-level median concentration. The maximum benzene concentration measured at SEWA is considerably less than the maximum benzene concentration measured across the program.
- Figure 29-7 is the box plot for 1,3-butadiene. Note that the program-level maximum concentration ($21.5 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to $1.5 \mu\text{g}/\text{m}^3$. This figure shows that the annual average 1,3-butadiene concentration for SEWA is greater than the program-level median concentration and less than the program-level third quartile. Figure 29-7 also shows that the maximum 1,3-butadiene concentration measured at SEWA is about one-fifth the scale of the box plot and considerably less than the maximum concentration measured across the program. It should be noted however, that the program-level average concentration is an order of magnitude less than the scale of the box plot and is being driven by a few measurements at the upper end of the concentration range.
- Figure 29-8 is the box plot for carbon tetrachloride. Similar to other VOCs, the program-level maximum concentration ($23.7 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot as the scale has been reduced to $2 \mu\text{g}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. This figure shows that the range of carbon tetrachloride concentrations measured at SEWA spans roughly $0.5 \mu\text{g}/\text{m}^3$. The annual average concentration of carbon tetrachloride for SEWA is just greater than the program-level average concentration and similar to the program-level third quartile, although less than $0.05 \mu\text{g}/\text{m}^3$ separates these three values.
- Figure 29-9 is the box plot for 1,2-dichloroethane. Note that the program-level maximum concentration ($111 \mu\text{g}/\text{m}^3$) is not shown directly on the box plot as the scale has been reduced to $1 \mu\text{g}/\text{m}^3$ in order to allow for the observation of data points at the lower end of the concentration range. All of the concentrations of 1,2-dichloroethane measured at SEWA are less than the program-level average concentration. The program-level average concentration for this pollutant is being driven by the highest concentrations measured at a few monitoring sites. The

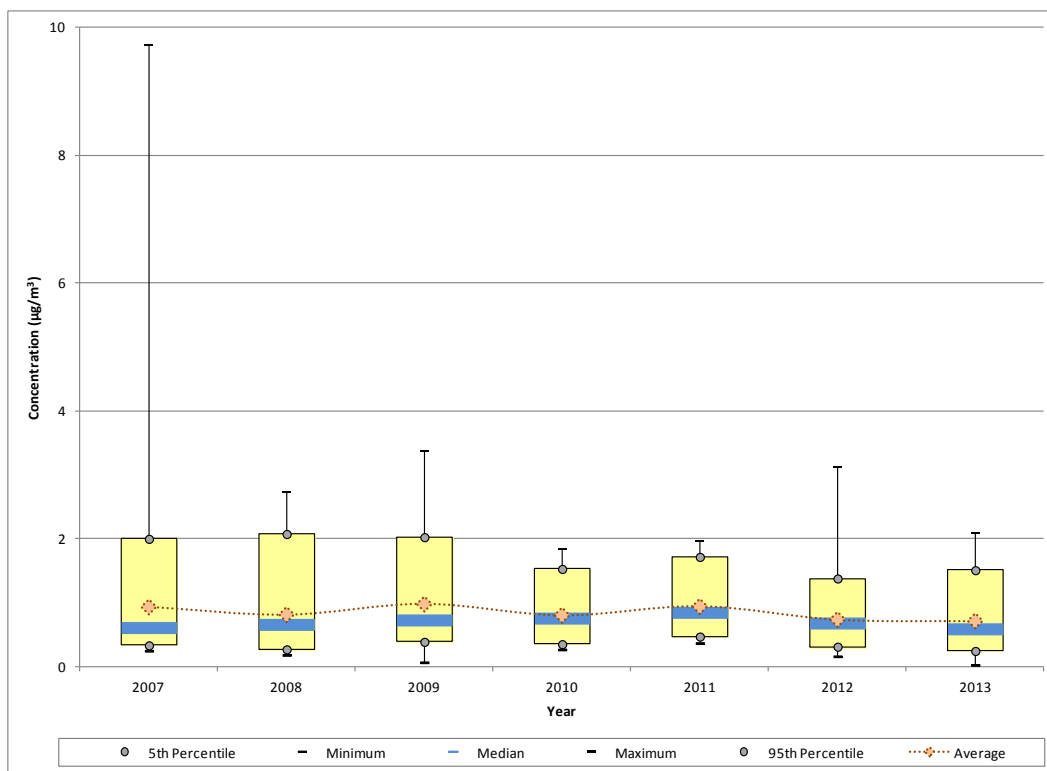
annual average concentration of 1,2-dichloroethane for SEWA falls between the program-level first quartile and second quartile (or median concentration).

- Figure 29-10 shows that the entire range of formaldehyde concentrations measured at SEWA is less than the program-level first quartile, indicating that all of SEWA's formaldehyde concentrations are less than the 25th percentile for the entire program dataset. This is also true for SEWA's annual average formaldehyde concentration. As previously discussed, SEWA has the lowest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds, both for 2013 and in previous years.
- Figure 29-11 shows that the annual average concentration of naphthalene for SEWA is just less than the program-level average concentration. The maximum naphthalene concentration measured at SEWA is considerably less than the program-level maximum concentration.
- Figure 29-12 is the box plot for nickel. Although the maximum nickel concentration measured at SEWA is less than half the maximum concentration measured across the program, it is the fourth highest concentration program-wide. This site has the second largest range of nickel concentrations measured among NMP sites sampling PM₁₀ metals. SEWA's annual average concentration is greater than the program-level average concentration and is the second highest annual average among NMP sites sampling PM₁₀ metals.

29.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.4.3.2. Sampling for PM₁₀ metals, VOCs, and carbonyl compounds under the NMP began in 2007 and sampling for PAHs began in 2008. Thus, Figures 29-13 through 29-21 present the 1-year statistical metrics for each of the pollutants of interest for SEWA. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average concentration is not provided, although the range and percentiles are still presented.

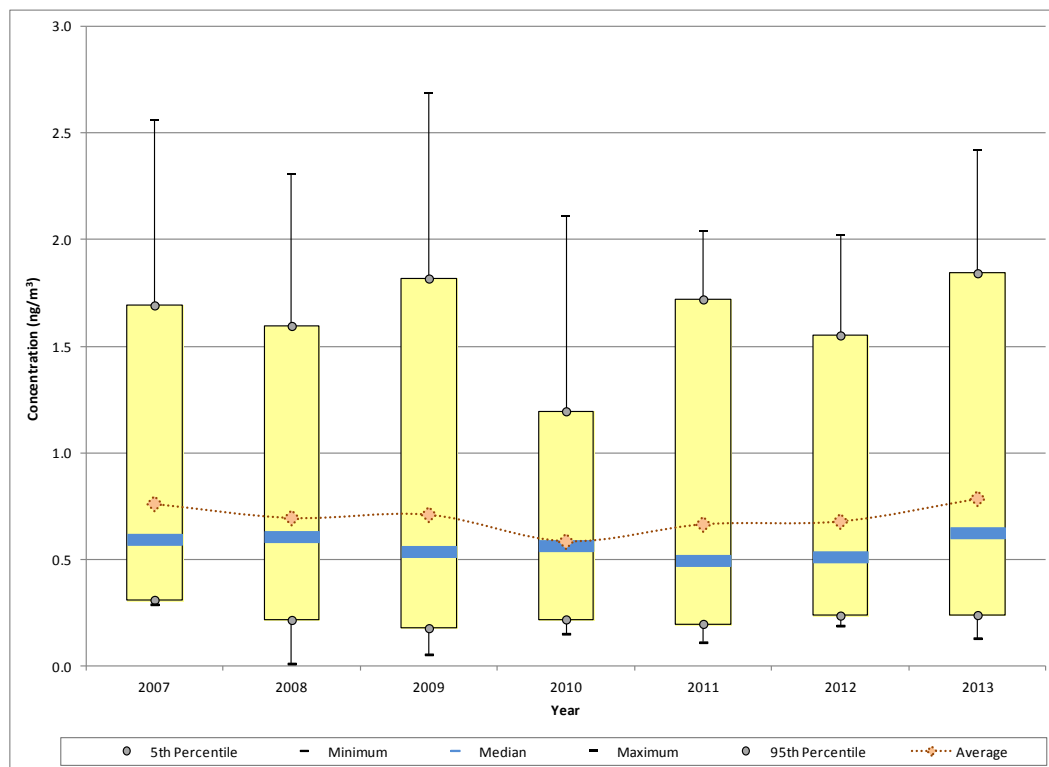
Figure 29-13. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at SEWA



Observations from Figure 29-13 for acetaldehyde measurements collected at SEWA include the following:

- The maximum acetaldehyde concentration was measured at SEWA on July 17, 2007 ($9.73 \mu\text{g}/\text{m}^3$). The next highest concentration is considerably less ($3.36 \mu\text{g}/\text{m}^3$, measured in September 2009). Only one other acetaldehyde concentration greater than $3 \mu\text{g}/\text{m}^3$ has been measured at SEWA (September 2012).
- The 1-year average concentrations have a slight undulating pattern, with years with slightly lower concentrations alternating with years with slightly higher concentrations. The 1-year average acetaldehyde concentration changed little from 2012 to 2013 and is at a minimum for 2013 compared to the other years of sampling. However, the range is rather small, with the 1-year average concentrations ranging from $0.72 \mu\text{g}/\text{m}^3$ (2013) to $0.98 \mu\text{g}/\text{m}^3$ (2009).
- The median concentration exhibits a steady increasing trend for the first 5 years of sampling, ranging from $0.61 \mu\text{g}/\text{m}^3$ (2007) to $0.85 \mu\text{g}/\text{m}^3$ (2011). The median then decreased from 2011 to 2012 ($0.68 \mu\text{g}/\text{m}^3$) and again for 2013 ($0.59 \mu\text{g}/\text{m}^3$), which is also the minimum for the entire sampling period. These changes, though, are also relatively small.

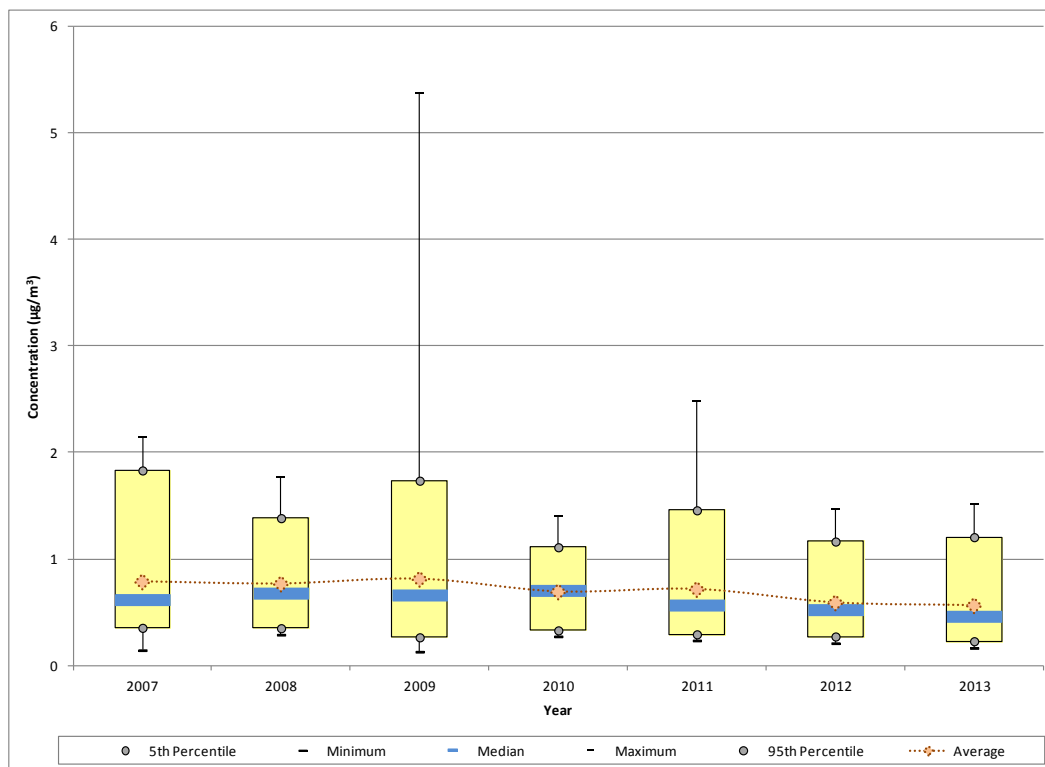
Figure 29-14. Yearly Statistical Metrics for Arsenic (PM₁₀) Concentrations Measured at SEWA



Observations from Figure 29-14 for arsenic (PM₁₀) measurements collected at SEWA include the following:

- The maximum arsenic concentration was measured at SEWA on January 19, 2009 (2.69 ng/m³), although a similar concentration was also measured in 2007 (2.56 ng/m³). The third highest arsenic concentration was measured in 2013 on January 22, 2013 (2.42 ng/m³). In total, 11 arsenic concentrations greater than 2 ng/m³ have been measured at SEWA, at least one in each year, although 2007 has the most (three).
- There have been no non-detects of arsenic measured at SEWA since the onset of sampling, including 2008, where it appears the minimum concentration is zero. For 2008, the minimum concentration of arsenic is 0.011 ng/m³.
- The 1-year average concentration fluctuated only slightly between 2007 and 2009, exhibits a decrease for 2010, after which an increasing trend is shown though the end of the sampling period, with the 1-year average concentration at a maximum for 2013. However, the 1-year average concentration has only varied by about 0.2 ng/m³, ranging from 0.58 ng/m³ (2010) to 0.79 ng/m³ (2013). Confidence intervals indicate that the changes are not statistically significant. The median concentration, also at a maximum for 2013, has varied by even less, from 0.50 ng/m³ (2011) to 0.63 ng/m³ (2013).

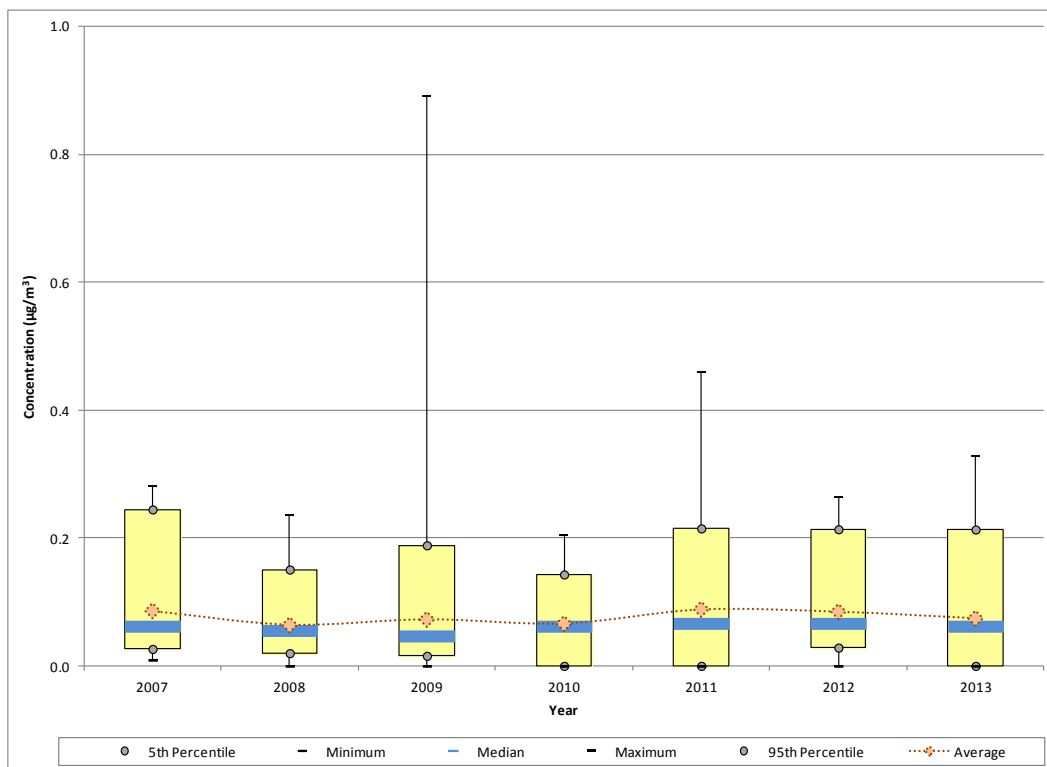
Figure 29-15. Yearly Statistical Metrics for Benzene Concentrations Measured at SEWA



Observations from Figure 29-15 for benzene measurements collected at SEWA include the following:

- The maximum benzene concentration was measured at SEWA on January 19, 2009 ($5.38 \mu\text{g}/\text{m}^3$), which is the same day the maximum arsenic concentration was measured. The next highest concentration was roughly half as high ($2.48 \mu\text{g}/\text{m}^3$, measured in January 2011). Only five benzene concentrations greater than $2 \mu\text{g}/\text{m}^3$ have been measured at SEWA.
- Overall, benzene concentrations have a slight decreasing trend at SEWA, although this decrease is interrupted by the 2 years that the highest benzene concentrations were measured. If the maximum concentrations measured in 2009 and 2011 were removed from the calculations, the 1-year average concentration would have a steady decreasing trend for the entire period, albeit slight. The 1-year average concentration of benzene has ranged from $0.56 \mu\text{g}/\text{m}^3$ (2013) to $0.81 \mu\text{g}/\text{m}^3$ (2009).
- The concentrations of benzene appear to have a seasonal trend at SEWA. Of the 66 benzene concentrations greater than $1 \mu\text{g}/\text{m}^3$, 55 have been measured during the colder months of the year, either during the first quarter (23) or fourth quarter (32) of any given year.

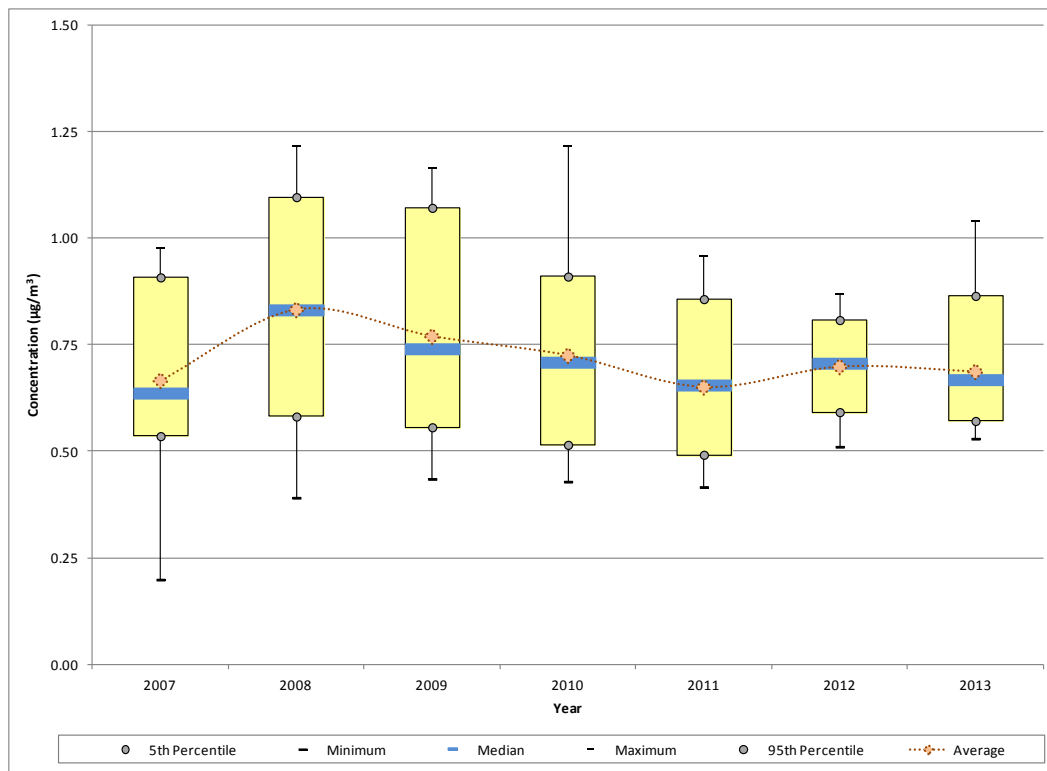
Figure 29-16. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at SEWA



Observations from Figure 29-16 for 1,3-butadiene measurements collected at SEWA include the following:

- The maximum 1,3-butadiene concentration ($0.89 \mu\text{g}/\text{m}^3$) was measured at SEWA on the same day as the maximum arsenic and benzene concentrations were measured, January 19, 2009. The next highest concentration was roughly half as high ($0.46 \mu\text{g}/\text{m}^3$) and was measured on the same day in January 2011 as the second highest benzene concentration.
- At least one non-detect has been measured each year at SEWA since the onset of sampling, with the exception of 2007, as indicated by the minimum concentration. For 2010, 2011, and 2013, both the minimum and 5th percentile are zero, indicating that at least 5 percent of the measurements were non-detects. Ten percent of the measurements were non-detects for 2010, 15 percent were non-detects for 2011, and 14 percent were non-detects for 2013. The percentage of non-detects is 3 percent for each of the remaining years.
- The 1-year average concentration has changed little over the years of sampling, ranging from $0.06 \mu\text{g}/\text{m}^3$ (2008) to $0.09 \mu\text{g}/\text{m}^3$ (2011). Interestingly, the year with the greatest number of non-detects (2011) also has the greatest number of measurements greater than $0.2 \mu\text{g}/\text{m}^3$ (seven).
- The 95th percentile is fairly static between 2011 and 2013, indicating that 95 percent of the measurements are less than $0.21 \mu\text{g}/\text{m}^3$ during each of these years.

Figure 29-17. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at SEWA

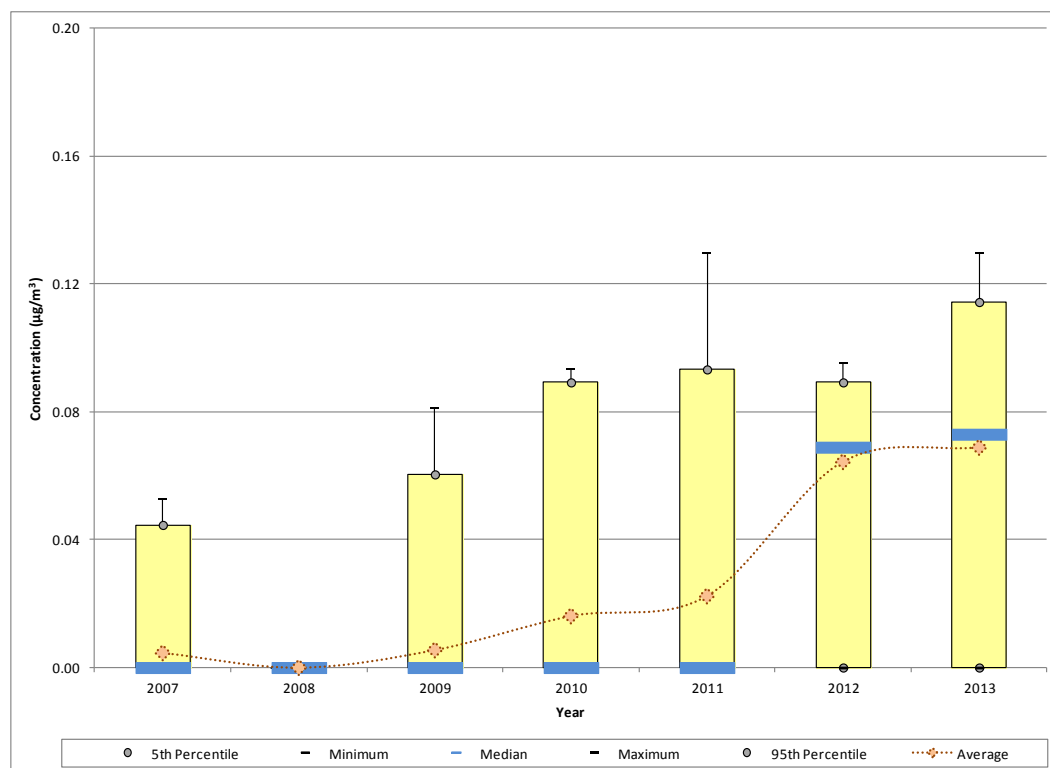


Observations from Figure 29-17 for carbon tetrachloride measurements collected at SEWA include the following:

- Nineteen concentrations of carbon tetrachloride greater than $1.0 \mu\text{g}/\text{m}^3$ have been measured since the onset of sampling in 2007. All but two of these were measured in 2008 and 2009, with one each in 2010 and 2013. The maximum carbon tetrachloride concentration ($1.22 \mu\text{g}/\text{m}^3$) has been measured twice at SEWA, once in 2008 and once in 2010.
- All of the statistical metrics increased from 2007 to 2008. Eleven concentrations measured in 2008 were greater than the maximum concentration measured in 2007. In addition, the number of carbon tetrachloride concentrations greater than $0.75 \mu\text{g}/\text{m}^3$ increased from 12 in 2007 to 43 for 2008.
- Between 2008 and 2011, a steady decreasing trend in the concentrations is shown, with the 1-year average concentration for 2011 returning to 2007 levels.
- The range of measurements tightened for 2012 and is the smallest range of measurements since the onset of sampling. Yet, both the 1-year average and median concentrations exhibit increases. As the number of concentrations falling into the $0.7 \mu\text{g}/\text{m}^3$ to $0.8 \mu\text{g}/\text{m}^3$ range doubled in 2012, from 14 for 2011 to 28 in 2012, the number of concentrations less than $0.6 \mu\text{g}/\text{m}^3$ fell from 20 to seven during this time frame.

- Despite the increase in the maximum concentration and the 95th percentile for 2013, both the 1-year average and median concentrations exhibit slight decreases, although the difference is not statistically significant.

Figure 29-18. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at SEWA

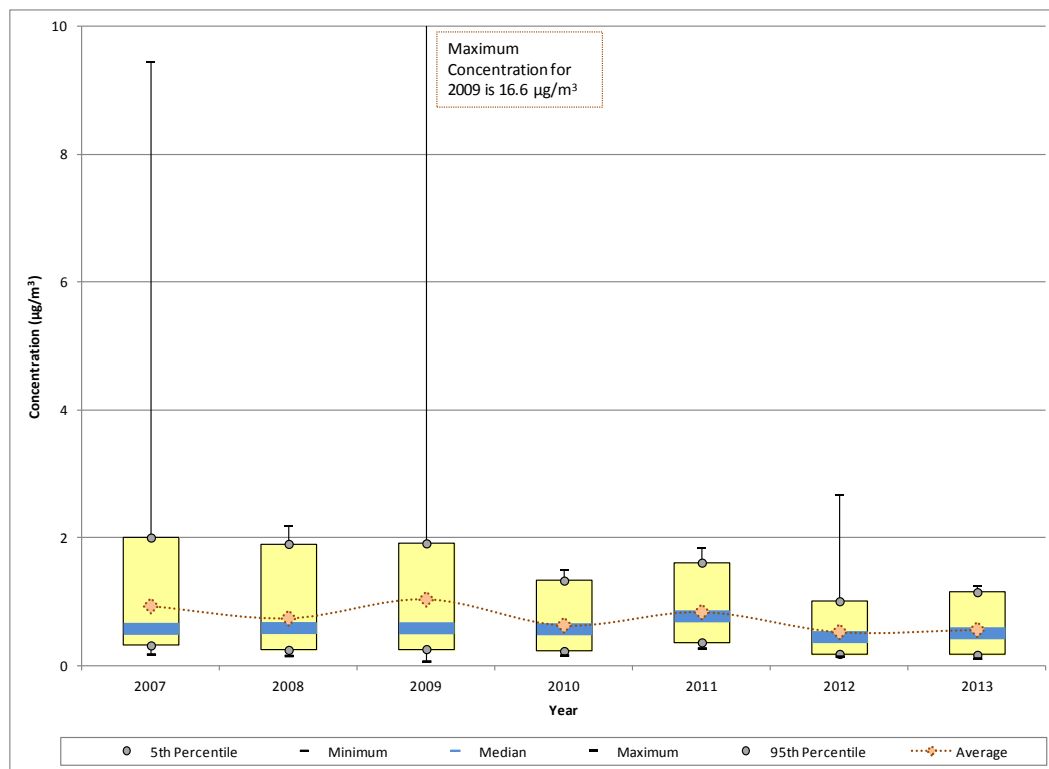


Observations from Figure 29-18 for 1,2-dichloroethane measurements collected at SEWA include the following:

- The minimum, 5th percentile, and median concentrations are zero for 2007 through 2011. This indicates that at least half of the measurements were non-detects. In 2008, there were no measured detections of 1,2-dichloroethane. The percentage of measured detections in 2007 and 2009 was around 10 percent, after which there is an increasing trend. For 2012, the percentage of measured detections is 93 percent, a considerable increase from 26 percent in 2011. This percentage leveled off a bit for 2013 (at 88 percent).
- As the number of measured detections increased, particularly for 2012 (and 2013), the median and 1-year average concentrations increased correspondingly. The median concentration is greater than the 1-year average concentration for 2012 and 2013. This is because there were still several non-detects (or zeros) factoring into the 1-year average concentration for these years, which can pull an average down in a similar manner that an outlier can drive an average upward, while the range of measured detections is rather small.

- Many of the statistical parameters are at a maximum for 2013, although the maximum concentration for 2013 is the same as the maximum concentration measured in 2011.

Figure 29-19. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at SEWA

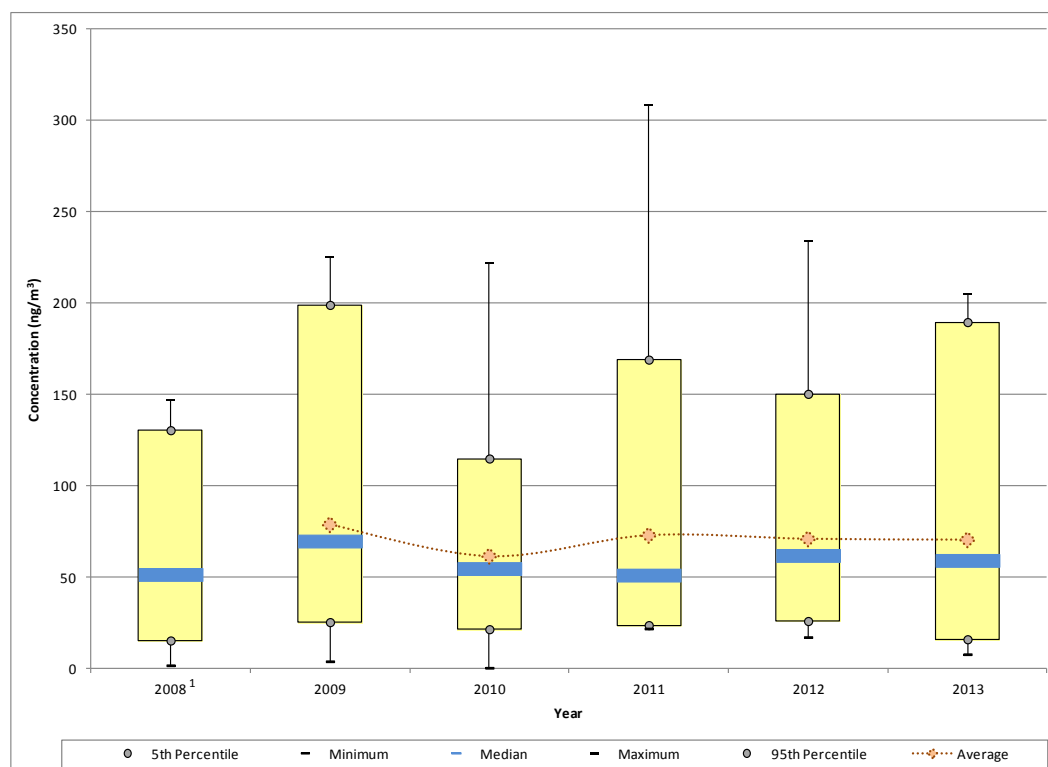


Observations from Figure 29-19 for formaldehyde measurements collected at SEWA include the following:

- The maximum formaldehyde concentration was measured at SEWA on January 13, 2009 ($16.6 \mu\text{g}/\text{m}^3$). The next highest concentration ($9.44 \mu\text{g}/\text{m}^3$) was measured on the same day in 2007 as the maximum acetaldehyde concentration. Only one other formaldehyde concentration greater than $3 \mu\text{g}/\text{m}^3$ has been measured at SEWA and was also measured in 2009. Only nine concentrations greater than $2 \mu\text{g}/\text{m}^3$ have been measured since the onset of carbonyl compound sampling at SEWA.
- The box and whisker plot for formaldehyde bears resemblance to the acetaldehyde plot. The 1-year average concentrations have an undulating pattern through 2012, with a “down” year followed by an “up” year. Between 2007 and 2012, the 1-year average formaldehyde concentrations have ranged from $0.53 \mu\text{g}/\text{m}^3$ (2012) to $1.04 \mu\text{g}/\text{m}^3$ (2009). The 1-year average formaldehyde concentration changed little from 2012 to 2013.

- The level of variability in the measurements decreased considerably from 2009 to 2010. The difference between the 1-year average and median concentrations is less than $0.1 \mu\text{g}/\text{m}^3$ for all years after 2009. Further, the difference between the 5th and 95th percentiles is less than $1 \mu\text{g}/\text{m}^3$ for 2012 and 2013, as the majority of measurements fell into a smaller range in these later years.

Figure 29-20. Yearly Statistical Metrics for Naphthalene Concentrations Measured at SEWA



¹ A 1-year average is not presented because sampling under the NMP did not begin until March 2008.

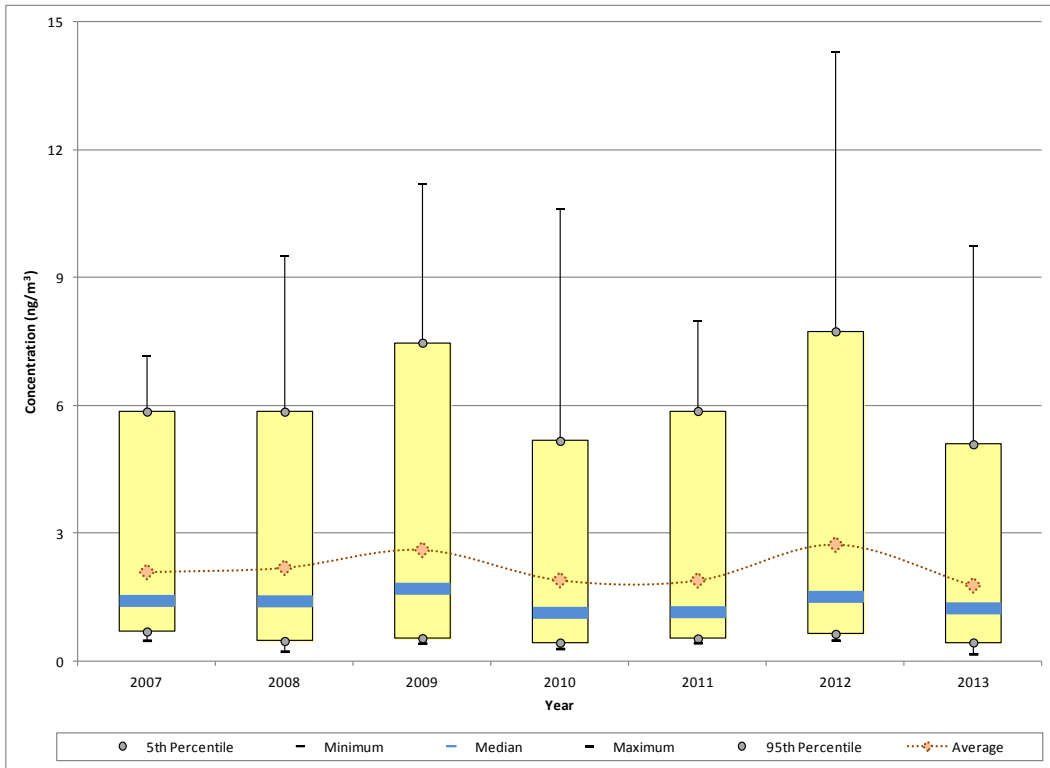
Observations from Figure 29-20 for naphthalene measurements collected at SEWA include the following:

- SEWA began sampling PAHs under the NMP in March 2008. Because a full year's worth of data is not available, a 1-year average concentration is not presented for 2008, although the range of measurements is provided.
- The maximum naphthalene concentration measured at SEWA was measured in 2011 ($308 \text{ ng}/\text{m}^3$). This is the only naphthalene measurement greater than $250 \text{ ng}/\text{m}^3$ measured at this site. Eight additional measurements greater than $200 \text{ ng}/\text{m}^3$ have been measured at SEWA and are spread across the years of sampling, except 2008.
- Each of the statistical parameters shown exhibits an increase from 2008 to 2009. Although the range of concentrations measured is similar for 2009 and 2010, the 95th percentile decreased by almost half from one year to the next. The number of naphthalene concentrations greater than $100 \text{ ng}/\text{m}^3$ decreased by nearly two-thirds,

from 19 in 2009 to only seven for 2010. With the exception of the median concentration, each of the statistical parameters exhibits an increase for 2011, with the 1-year average concentration nearly returning to 2009 levels. This is partially driven by the maximum concentration measured this year.

- Little change in the 1-year average concentration is shown between 2011 and 2013.

Figure 29-21. Yearly Statistical Metrics for Nickel (PM₁₀) Concentrations Measured at SEWA



Observations from Figure 29-21 for nickel measurements collected at SEWA include the following:

- The two highest concentrations of nickel (14.3 ng/m³ and 11.8 ng/m³) were both measured at SEWA in 2012, although concentrations greater than 10 ng/m³ were also measured in 2009 (two) and 2010 (one).
- The 1-year average concentration exhibits an increasing trend between 2007 and 2009, after which a decrease is shown for 2010, with little change for 2011. An increase in the 1-year average concentration is shown for 2012, which is followed by a decrease for 2013. Confidence intervals calculated on the dataset indicate that the changes shown are not statistically significant as the concentrations measured are fairly variable from year-to-year. The median concentrations exhibit a similar pattern.

- The difference between the 1-year average and median concentrations is greater than 0.50 ng/m³ for all years (and greater than 1.0 ng/m³ for 2012). This indicates that there is considerable variability in the measurements of nickel.

29.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk related to air toxics at the Washington monitoring site. Refer to Sections 3.2, 3.4.3.3, and 3.4.3.4 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

29.5.1 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Washington site and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers may want to shift their air monitoring priorities. Refer to Section 3.4.3.3 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 29-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Observations from Table 29-6 for SEWA include the following:

- The pollutants with the highest annual average concentrations for SEWA are acetaldehyde, carbon tetrachloride, formaldehyde, and benzene.
- The pollutants with the highest cancer risk approximations are formaldehyde, benzene, carbon tetrachloride, and arsenic. The cancer risk approximation for formaldehyde for SEWA is the lowest among this pollutant's site-specific cancer risk approximations.
- The noncancer hazard approximations for SEWA are all considerably less than 1.0, with the highest calculated for acetaldehyde (0.08), indicating that no adverse noncancer health effects are expected from these individual pollutants.

Table 29-6. Risk Approximations for the Washington Monitoring Site

Pollutant	Cancer URE ($\mu\text{g}/\text{m}^3$) ⁻¹	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu\text{g}/\text{m}^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Seattle, Washington - SEWA						
Acetaldehyde	0.0000022	0.009	57/57	0.72 ± 0.11	1.58	0.08
Benzene	0.0000078	0.03	57/57	0.56 ± 0.08	4.37	0.02
1,3-Butadiene	0.00003	0.002	49/57	0.07 ± 0.02	2.23	0.04
Carbon Tetrachloride	0.000006	0.1	57/57	0.69 ± 0.03	4.12	0.01
1,2-Dichloroethane	0.000026	2.4	51/57	0.07 ± 0.01	1.82	<0.01
Formaldehyde	0.000013	0.0098	57/57	0.57 ± 0.08	7.37	0.06
Arsenic (PM ₁₀) ^a	0.0043	0.000015	60/60	0.79 ± 0.13	3.38	0.05
Naphthalene ^a	0.000034	0.003	57/57	70.39 ± 13.09	2.39	0.02
Nickel (PM ₁₀) ^a	0.00048	0.00009	60/60	1.78 ± 0.44	0.86	0.02

^a Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

29.5.2 Risk-Based Emissions Assessment

In addition to the risk-based screening discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 29-7 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 29-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. Lastly, Table 29-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for SEWA, as presented in Table 29-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 29-7. Table 29-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 29-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Washington Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Seattle, Washington (King County) - SEWA					
Benzene	930.96	Formaldehyde	1.01E-02	Formaldehyde	7.37
Formaldehyde	776.28	Benzene	7.26E-03	Benzene	4.37
Ethylbenzene	460.42	1,3-Butadiene	4.24E-03	Carbon Tetrachloride	4.12
Acetaldehyde	442.08	Naphthalene	2.98E-03	Arsenic	3.38
1,3-Butadiene	141.43	POM, Group 2b	1.76E-03	Naphthalene	2.39
Tetrachloroethylene	95.67	POM, Group 2d	1.16E-03	1,3-Butadiene	2.23
Naphthalene	87.72	Ethylbenzene	1.15E-03	1,2-Dichloroethane	1.82
POM, Group 2b	19.97	POM, Group 5a	1.11E-03	Acetaldehyde	1.58
POM, Group 2d	13.20	Acetaldehyde	9.73E-04	Nickel	0.86
Trichloroethylene	11.73	Nickel, PM	5.36E-04		

Table 29-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Washington Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Seattle, Washington (King County) - SEWA					
Toluene	4,999.08	Acrolein	2,910,205.08	Acetaldehyde	0.08
Xylenes	1,895.75	Formaldehyde	79,212.57	Formaldehyde	0.06
Hexane	1,472.55	1,3-Butadiene	70,716.54	Arsenic	0.05
Methanol	1,144.61	Cyanide Compounds, gas	63,595.60	1,3-Butadiene	0.04
Benzene	930.96	Acetaldehyde	49,120.41	Naphthalene	0.02
Formaldehyde	776.28	Benzene	31,032.01	Nickel	0.02
Ethylbenzene	460.42	Naphthalene	29,239.94	Benzene	0.02
Ethylene glycol	455.61	Xylenes	18,957.50	Carbon Tetrachloride	0.01
Acetaldehyde	442.08	Lead, PM	16,900.94	1,2-Dichloroethane	<0.01
Methyl isobutyl ketone	205.29	Nickel, PM	12,405.52		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.4.3.4. Similar to the cancer risk and noncancer hazard approximations provided in Section 29.5.1, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 29-7 for SEWA include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in King County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for King County are formaldehyde, benzene, and 1,3-butadiene.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for King County.
- Formaldehyde and benzene have the highest cancer risk approximations for SEWA. These two pollutants top both emissions-based lists as well. Naphthalene, 1,3-butadiene, and acetaldehyde also appear on all three lists.
- Carbon tetrachloride and arsenic, which rank third and fourth, respectively, for cancer risk approximations for SEWA, do not appear on either emissions-based list. This is also true for 1,2-dichloroethane. Nickel, which appears ninth among the pollutants of interest for SEWA, has the 10th highest toxicity-weighted emissions for King County, but is not among the highest emitted (of the pollutants with cancer UREs).
- POM, Group 2b is the eighth highest emitted "pollutant" in King County and ranks fifth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at SEWA including acenaphthene, fluorene, and perylene. Although concentrations of acenaphthene and fluorene each failed screens, these pollutants were not identified as pollutants of interest for SEWA. POM, Group 2d ranks ninth for total emissions and sixth for its toxicity-weighted emissions. POM, Group 2d includes several PAHs sampled for at SEWA including anthracene, phenanthrene, and pyrene. POM, Group 5a also has the eighth highest toxicity-weighted emissions for King County. Benzo(a)pyrene is part of POM, Group 5a. None of the PAHs included in POM, Groups 2d and 5a failed screens for SEWA.

Observations from Table 29-8 for SEWA include the following:

- Toluene, xylenes, and hexane are the highest emitted pollutants with noncancer RfCs in King County. The quantity of the emissions of these pollutants are considerably higher than the emissions for the pollutants topping the emissions-based list in Table 29-7.
- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for King County, followed by formaldehyde and 1,3-butadiene. Although acrolein was sampled for at SEWA, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.
- Four of the highest emitted pollutants also have the highest toxicity-weighted emissions for King County.
- Acetaldehyde, formaldehyde, and benzene appear on all three lists in Table 29-8.
- Naphthalene, 1,3-butadiene, and nickel are among SEWA's pollutants of interest that also appear among those with the highest toxicity-weighted emissions, although none of these appear among the highest emitted (of those with a noncancer RfC).
- Arsenic, carbon tetrachloride, and 1,2-dichloroethane are pollutants of interest for SEWA that appear on neither emissions-based list.

29.6 Summary of the 2013 Monitoring Data for SEWA

Results from several of the data treatments described in this section include the following:

- ❖ *Fourteen pollutants failed at least one screen for SEWA.*
- ❖ *Acetaldehyde had the highest annual average concentration for SEWA, although all of the pollutants of interest for SEWA had annual average concentrations less than 1 $\mu\text{g}/\text{m}^3$.*
- ❖ *The annual average concentration of nickel for SEWA is the second highest among NMP sites sampling PM_{10} metals. The annual average concentration of carbon tetrachloride for SEWA is the third highest among NMP sites sampling VOCs. Conversely, the annual average concentration of formaldehyde for SEWA is the lowest among NMP sites sampling carbonyl compounds.*
- ❖ *Concentrations of most of the pollutants of interest for SEWA have changed little in recent years. Concentrations of carbon tetrachloride exhibited a decreasing trend over much of the sampling period, although this trend did not continue into the later years of sampling. The number of non-detects of 1,2-dichloroethane has been decreasing considerably at SEWA, particularly in recent years.*

30.0 Sites in Wisconsin

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Wisconsin, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

30.1 Site Characterization

This section characterizes the monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The HOWI monitoring site is located in Horicon, Wisconsin and is the relocated Mayville NATTS site. The MIWI site is located in Milwaukee. Figure 30-1 is the composite satellite image retrieved from ArcGIS Explorer showing the HOWI monitoring site and its immediate surroundings. Figure 30-2 identifies nearby point source emissions locations for this site by source category, as reported in the 2011 NEI for point sources, version 2. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 30-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile boundary are still visible on the map for reference, but have been grayed out in order to emphasize emissions sources within the boundary. Figures 30-3 and 30-4 are the composite satellite image and emissions sources map for MIWI. Table 30-1 provides supplemental geographical information such as land use, location setting, and locational coordinates for each site.

Figure 30-1. Horicon, Wisconsin (HOWI) Monitoring Site



Figure 30-2. NEI Point Sources Located Within 10 Miles of HOWI

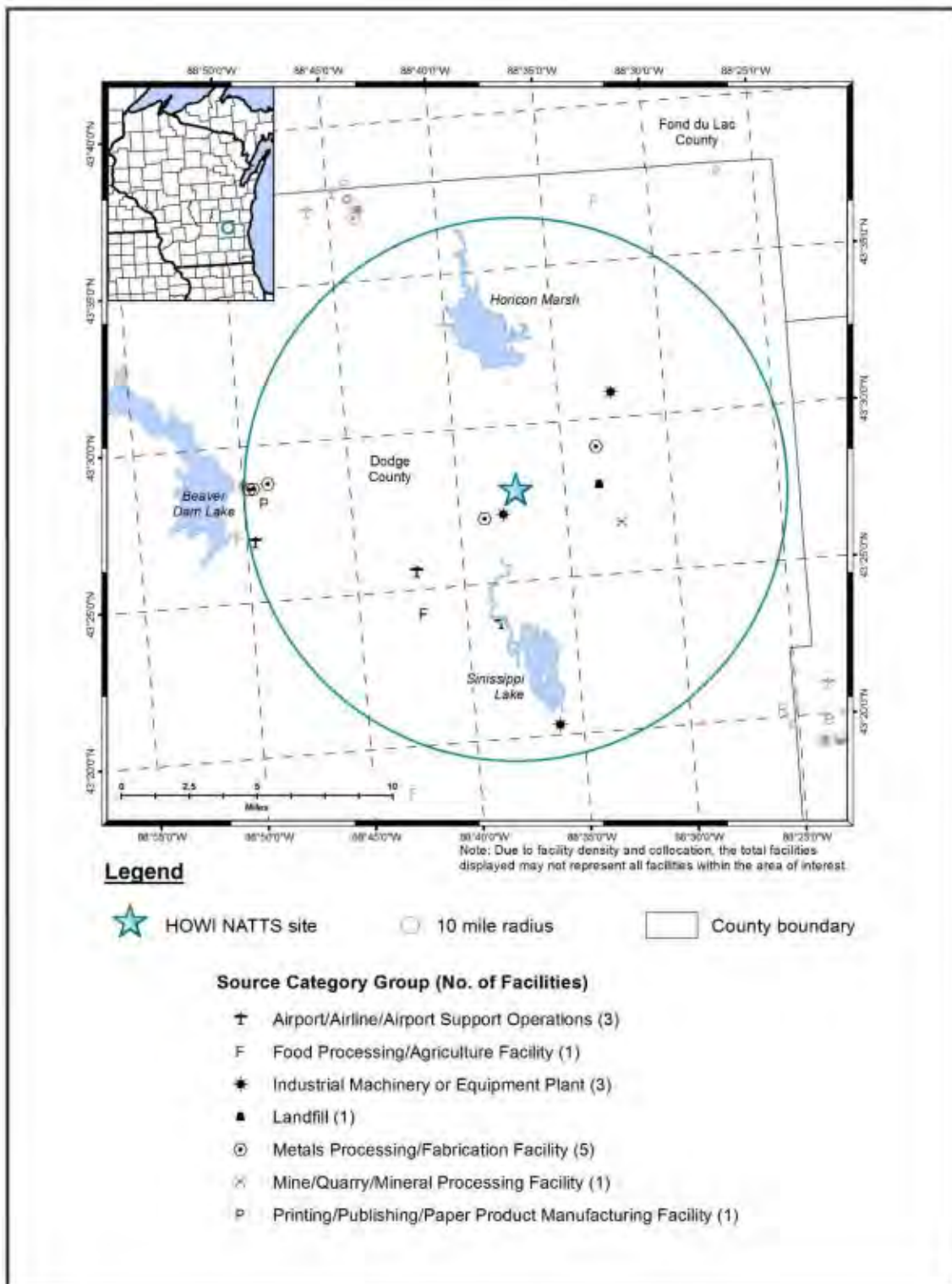


Figure 30-3. Milwaukee, Wisconsin (MIWI) Monitoring Site



Figure 30-4. NEI Point Sources Located Within 10 Miles of MIWI

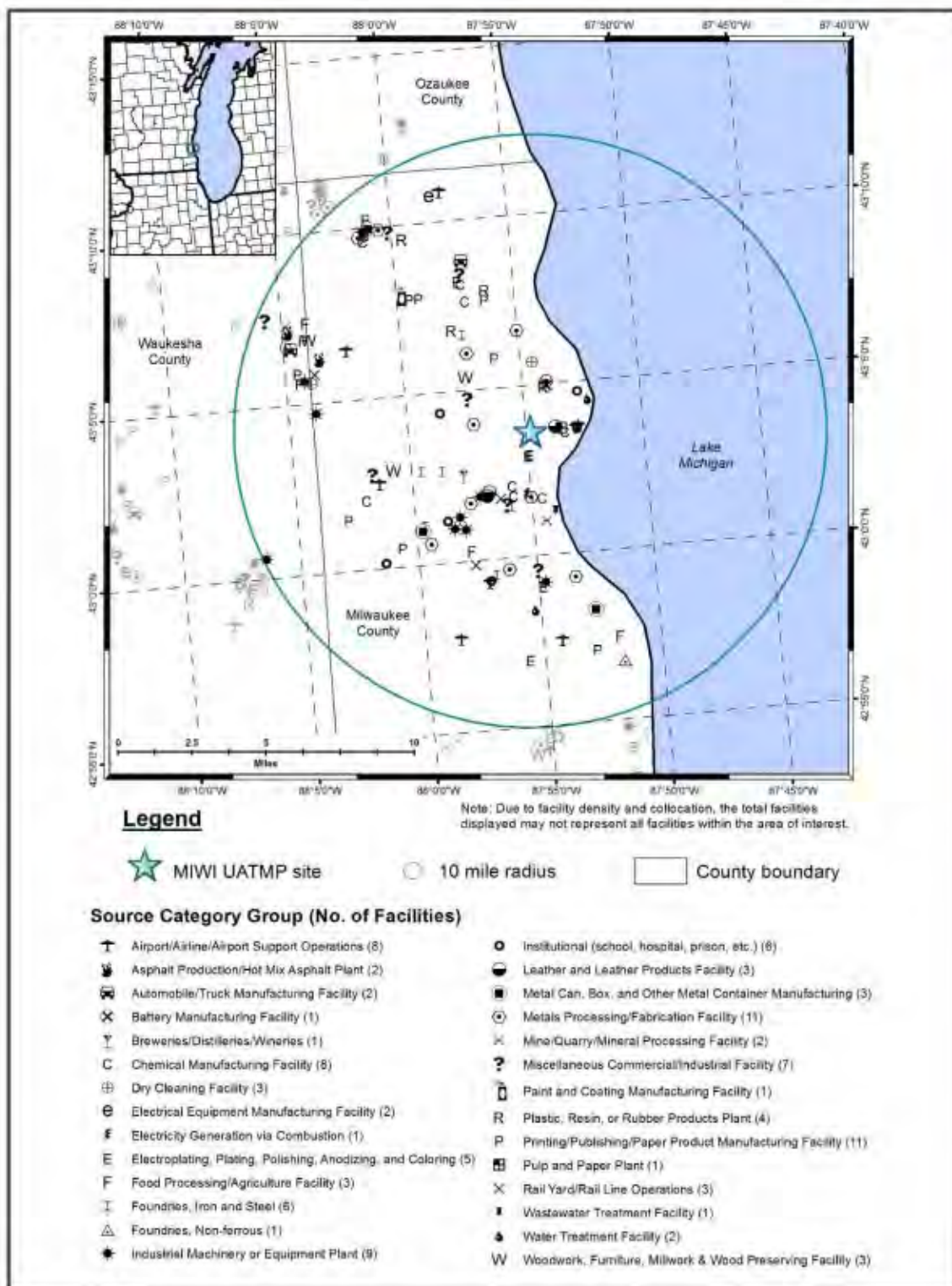


Table 30-1. Geographical Information for the Wisconsin Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information ¹
HOWI	55-027-0001	Horicon	Dodge	Beaver Dam, WI	43.466111, -88.621111	Agricultural	Rural	SVOCs, PCBs, CO, SO ₂ , NO _y , NO, VOCs, Carbonyl compounds, O ₃ , Meteorological parameters, PM ₁₀ , PM ₁₀ Metals, PM Coarse, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.
MIWI	55-079-0026	Milwaukee	Milwaukee	Milwaukee-Waukesha-West Allis, WI	43.061258, -87.913520	Commercial	Urban/City Center	PAMS/NMOCs, SO ₂ , NO _y , NO, NO ₂ , NO _x , Carbonyl compounds, Hg, O ₃ , Meteorological parameters, PM ₁₀ , PM Coarse, PM _{2.5} , PM _{2.5} Speciation, IMPROVE Speciation.

¹Data for additional pollutants are reported to AQS for these sites (EPA, 2014b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The HOWI monitoring site is located just north of the town of Horicon, in southeast Wisconsin, within the boundaries of the Horicon Marsh Wildlife Area. HOWI is located roughly in the center of a triangle formed by Milwaukee (37 miles to the southeast), Madison (41 miles to the southwest), and Fond Du Lac (20 miles to the northeast). The surrounding area is rural and agricultural in nature, although a residential subdivision is located less than one-half mile south of the site. The HOWI monitoring site serves as a rural background site for the NATTS program. However, the area is affected by nearby urban areas, and thus, could show the effects on the wildlife sanctuary. State Highway 28, which can be seen on the right-hand side of Figure 30-1, is the closest major roadway. The Rock River is located just west of the site and can be seen on the left hand side of Figure 30-1. Figure 30-2 shows that two point sources are located just south and west of HOWI, in the town of Horicon. The closest point source to HOWI is an industrial machinery or equipment plant. The source categories with the most emissions sources within 10 miles of HOWI are metal processing/fabrication facilities; airport and airport support operations, which include airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; and industrial machinery or equipment plants.

The city of Milwaukee is located in southeast Wisconsin on the western shores of Lake Michigan. The MIWI monitoring site is located in the parking lot behind the Wisconsin Department of Natural Resources headquarters building. The site is located in a commercial area surrounded by residential areas, as shown in Figure 30-3. Interstate-43 runs north-south less than one-half mile west of the site. The Milwaukee River runs roughly north-south less than 1 mile east of the site with the Milwaukee Bay and Lake Michigan approximately 2 miles farther east. Figure 30-4 shows this proximity to Lake Michigan as well as the numerous point sources within 10 miles of MIWI. A cluster of point sources is located to the east of the site as well as to the south. The source categories with the most emissions sources within 10 miles of MIWI are metals processing/fabrication; printing, publishing, and paper product manufacturing; industrial machinery or equipment; chemical manufacturing; and airport and airport support operations. Within about 1 mile of MIWI are two electroplating, plating, polishing, anodizing, and coloring facilities to the south and a pulp and paper plant and a leather and leather products facility to the east.

Table 30-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Wisconsin monitoring sites. Table 30-2 includes both county-level population and vehicle registration information. Table 30-2 also contains traffic volume information for HOWI and MIWI as well as the location for which each traffic volume was obtained. Additionally, Table 30-2 presents the county-level daily VMT for Dodge County and Milwaukee County.

Table 30-2. Population, Motor Vehicle, and Traffic Information for the Wisconsin Monitoring Sites

Site	County	Estimated County Population ¹	County-level Vehicle Registration ²	Annual Average Daily Traffic ³	Intersection Used for Traffic Data	County-level Daily VMT ⁴
HOWI	Dodge	88,344	99,078	5,100	Hwy 28 (Clason St), north of Hwy 33 in Horicon	2,568,234
MIWI	Milwaukee	956,023	641,582	12,400	N Dr Martin Luther King Jr Dr, north of W North Ave	16,098,216

¹County-level population estimates reflect 2013 data (Census Bureau, 2014)

²County-level vehicle registrations reflect 2013 data (WI DOT, 2013)

³AADT reflects 2011 data for HOWI and 2013 data for MIWI (WI DOT, 2014a)

⁴County-level VMT reflects 2013 data (WI DOT, 2014b)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 30-2 include the following:

- Dodge County's population is an order of magnitude less than the population for Milwaukee County and in the bottom-third compared to other counties with NMP sites. This is not unexpected given the rural nature of the area. Conversely, Milwaukee County's population is in the top third compared to other counties with NMP sites.
- The county-level vehicle registration for HOWI is considerably less than the vehicle registration for MIWI, ranking similarly to the rankings for population among other counties with NMP sites. The county-level vehicle registration for MIWI is not as high as its ranking for population compared to other NMP sites, putting it in the middle third of the range.
- The traffic volume near MIWI is more than twice the traffic volume near HOWI. The traffic volume near HOWI is also on the low end compared to other NMP sites while the traffic near MIWI falls in the middle of the range. The traffic estimate provided for HOWI is for Highway 28 (Clason Street) near Highway 33 on the east side of Horicon. The traffic estimate for MIWI is for N. Martin Luther King Jr. Drive, north of W. North Avenue.

- The daily VMT for Milwaukee County is considerably higher than the VMT for Dodge County. VMTs for these sites rank 19th and 38th, respectively, compared to VMTs for other counties with NMP sites.

30.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Wisconsin on sample days, as well as over the course of the year.

30.2.1 Climate Summary

HOWI and MIWI are both located in southeast Wisconsin. The city of Milwaukee is located along the western shores of Lake Michigan, while the town of Horicon is located less than 40 miles west of Lake Michigan, between the towns of West Bend and Beaver Dam. The climate in this part of the state is continental in nature, with an active weather pattern, as storm systems frequently move eastward across the region. Lake Michigan has a significant influence on the area, although the town of Horicon is far enough inland to limit some of the moderating influences of the lake. Precipitation falls predominantly in the spring and summer months, with thunderstorms most common in the summer. Summers tend to be mild, although southerly winds out of the Gulf of Mexico can occasionally advect warm, humid air into the area while easterly winds off Lake Michigan have a cooling effect on the Milwaukee area. Winters are cold and snowfall is common, with an annual average snowfall around 50 inches near Milwaukee. Lake Michigan can moderate cold air masses moving in from the north and may induce lake-effect snow events. Lake effect snows can occur with winds with a northeasterly and easterly component, although lake effect snows are often reduced farther inland. The number of days per season with at least 1 inch snow cover on the ground can range from less than 20 days to greater than 100 days (Wood, 2004; WI SCO, 2015a and 2015b).

30.2.2 Meteorological Summary

Hourly meteorological data for 2013 were retrieved from NCDC for the weather stations closest to the Wisconsin monitoring sites (NCDC, 2013), as described in Section 3.4.2. The closest weather stations are located at Dodge County Airport near HOWI and Lawrence J. Timmerman Airport near MIWI (WBANs 04898 and 94869, respectively). Additional information about these weather stations, such as the distance between each site and the weather station, is provided in Table 30-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 30-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), and wind (average scalar wind speed) information for days samples were collected and for all of 2013. Average pressure information is not provided because sea level pressure observations were not recorded at either weather station. Also included in Table 30-3 is the 95 percent confidence interval for each parameter. As shown in Table 30-3, average meteorological conditions on sample days near HOWI appear cooler than conditions experienced throughout the year. However, sampling under the NMP at HOWI concluded in June, thereby missing the second half of the year, which also includes the warmest days of the year. Average meteorological conditions on sample days near MIWI are significantly colder and drier than conditions experienced throughout the year. Sampling under the NMP at MIWI concluded in March; thus, the sample day averages incorporate only meteorological data for the first 3 months of the year.

Table 30-3. Average Meteorological Conditions near the Wisconsin Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type ¹	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Horicon, Wisconsin - HOWI									
Dodge County Airport 04898 (43.43, -88.70)	5.0 miles	Sample Days (30)	47.3 ± 7.8	39.8 ± 7.2	30.0 ± 6.9	35.7 ± 6.5	71.7 ± 6.2	NA	7.1 ± 1.1
	236° (SW)	2013	52.9 ± 2.3	44.9 ± 2.2	34.1 ± 2.0	40.1 ± 1.9	69.4 ± 1.4	NA	7.0 ± 0.3
Milwaukee, Wisconsin - MIWI									
Lawrence J. Timmerman Airport 94869 (43.11, -88.03)	6.8 miles	Sample Days (12)	29.9 ± 5.6	24.1 ± 6.2	17.9 ± 7.7	22.3 ± 6.2	78.1 ± 7.1	NA	8.0 ± 1.9
	299° (WNW)	2013	53.9 ± 2.2	45.9 ± 2.1	35.3 ± 2.0	41.0 ± 1.9	69.7 ± 1.2	NA	6.8 ± 0.3

¹ Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA = Sea level pressure was not recorded at either airport.

30.2.3 Wind Rose Comparison

Hourly surface wind data from the weather stations nearest HOWI and MIWI were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.4.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

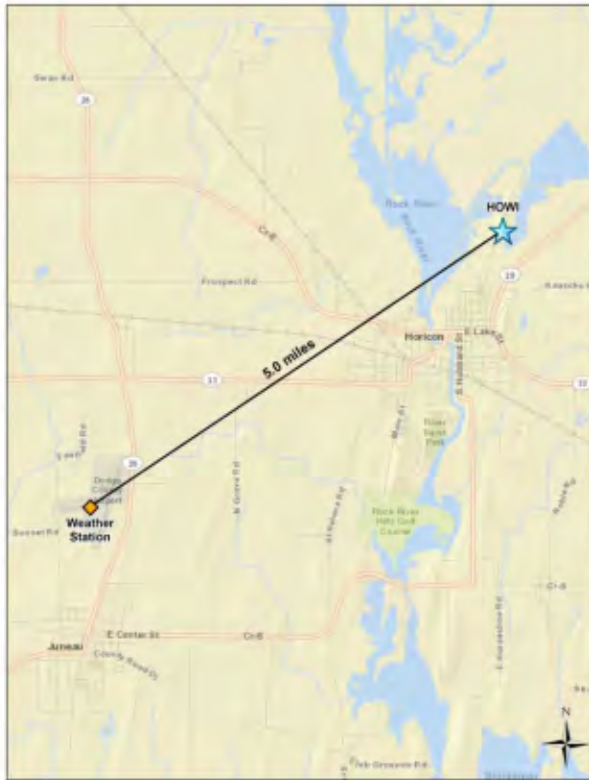
Figure 30-5 presents a map showing the distance between the weather station and HOWI, which may be useful for identifying topographical influences that can affect the meteorological patterns experienced at this location. Figure 30-5 also presents three different wind roses for the HOWI monitoring site. First, a historical wind rose representing 2003 to 2012 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2013 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2013 is presented. These can be used to identify the predominant wind speed and direction for 2013 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 30-6 presents the distance map and three wind roses for MIWI.

Observations from Figure 30-5 for HOWI include the following:

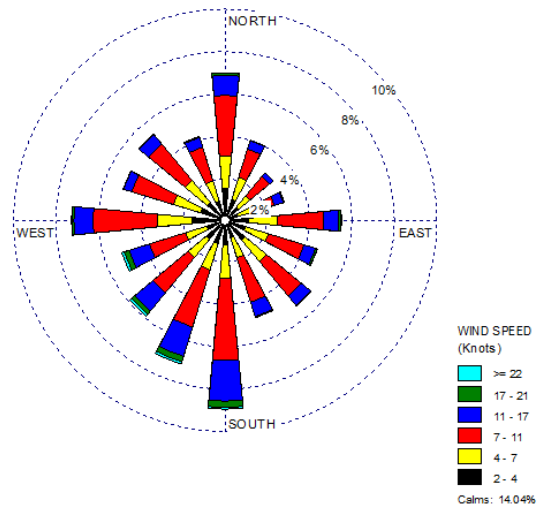
- The Dodge County Airport weather station is located 5 miles southwest of HOWI.
- The historical wind rose shows that winds from a variety of directions were observed near HOWI. Winds from the south, southwest quadrant, and west account for one-third of wind observations. Northerly winds are the only other winds to individually account for at least 6 percent of the winds near HOWI. The strongest wind speeds were associated with southerly to west-southwesterly winds. Calm winds (those less than or equal to 2 knots) were observed for 14 percent of the hourly measurements.
- The wind patterns shown on the 2013 wind rose resemble the historical wind patterns, although the percentage of calm winds was less than 11 percent in 2013.
- The sample day wind rose shows that winds from the north, north-northeast, and east accounted for the highest percentage of wind observations on sample days at HOWI, which is different than the percentages shown on the historical and full-year wind roses. However, the sample day wind rose includes wind observations for January through June only, due to the completion of sampling at this site. A full year’s worth of wind observations may look differently.

Figure 30-5. Wind Roses for the Dodge County Airport Weather Station near HOWI

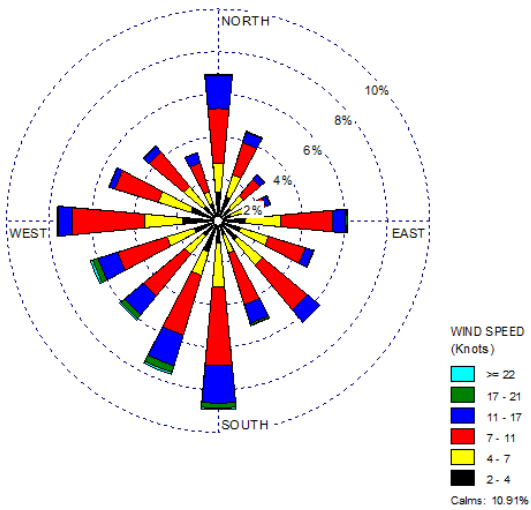
Location of HOWI and Weather Station



2003-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose

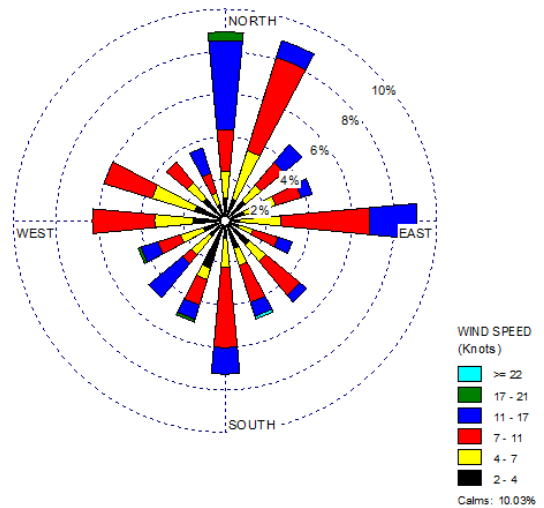
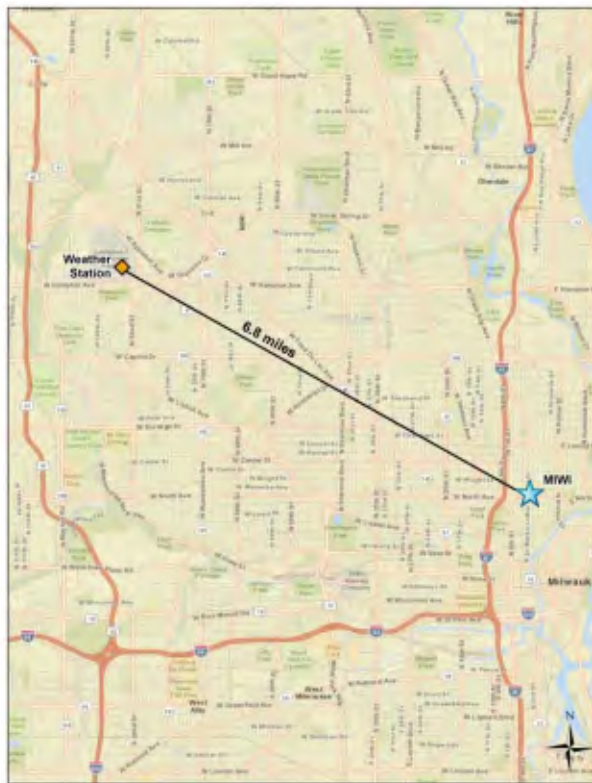
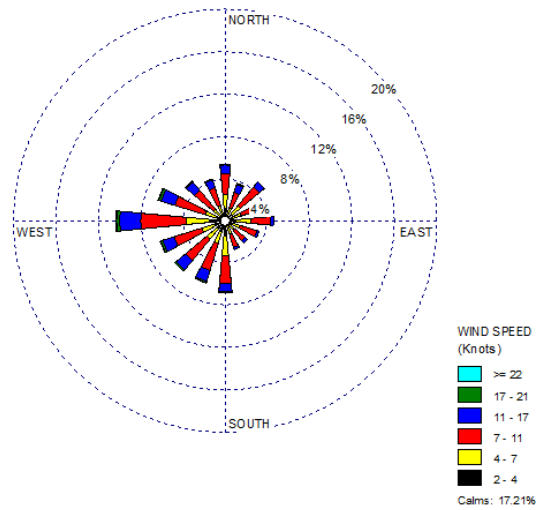


Figure 30-6. Wind Roses for the Lawrence J. Timmerman Airport Weather Station near MIWI

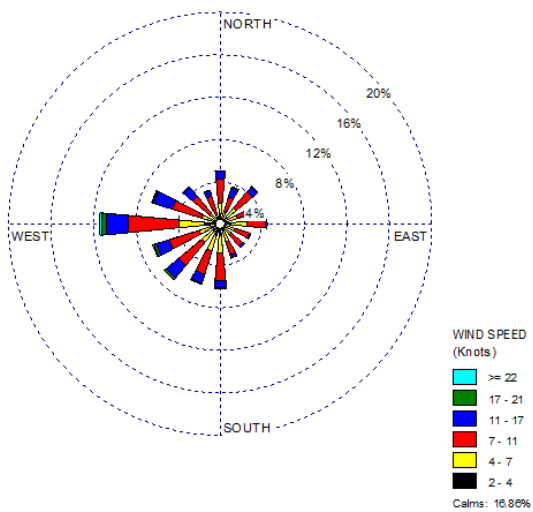
Location of MIWI and Weather Station



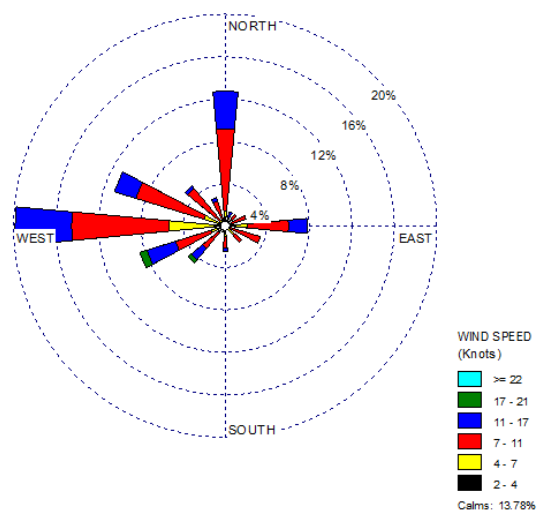
2006-2012 Historical Wind Rose



2013 Wind Rose



Sample Day Wind Rose



Observations from Figure 30-6 for MIWI include the following:

- The Timmerman Airport weather station is located less than 7 miles west-northwest of MIWI. Note that the airport location is considerably farther from Lake Michigan than the monitoring site location.
- The historical wind rose shows that winds from a variety of directions were observed near MIWI, although westerly winds account for the greatest number of observations greater than 2 knots (10 percent). Winds with a westerly component were observed more frequently than winds with an easterly component. Calm winds were observed for approximately 17 percent of the hourly measurements.
- The wind patterns shown on the 2013 wind rose resemble the historical wind patterns, indicating that wind conditions in 2013 were similar to those observed historically.
- While westerly winds were still the most frequently observed wind direction on sample days near MIWI, this is one of the few similarities the full-year and sample day wind roses share. However, the sample day wind rose includes wind observations for January, February, and March only, due to the completion of the monitoring effort at this site. A full year's worth of wind observations may look differently.

30.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Wisconsin monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 30-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 30-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Only hexavalent chromium was sampled for at these two sites. However, sampling was discontinued at MIWI in mid-March and at HOWI in June.

Table 30-4. Risk-Based Screening Results for the Wisconsin Monitoring Sites

Pollutant	Screening Value ($\mu\text{g}/\text{m}^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Horicon, Wisconsin - HOWI						
Hexavalent Chromium	0.000083	0	4	0.00	0.00	0.00
Total		0	4	0.00		
Milwaukee, Wisconsin - MIWI						
Hexavalent Chromium	0.000083	0	8	0.00	0.00	0.00
Total		0	8	0.00		

Observations from Table 30-4 include the following:

- Thirty hexavalent chromium samples were collected at HOWI prior to the discontinuation of sampling. This pollutant was detected in only four of the samples collected at HOWI.
- Hexavalent chromium did not fail any screens during the 2013 monitoring effort at HOWI. This was also true for 2011 and 2012.
- Eleven hexavalent chromium samples were collected at MIWI prior to the discontinuation of sampling. This pollutant was detected in eight of the samples collected at MIWI.
- Hexavalent chromium did not fail any screens during the 2013 portion of the monitoring effort at MIWI.

30.4 Concentrations

This section typically presents various concentration averages used to characterize pollution levels at the monitoring sites for each of the site-specific pollutants of interest. However, because there were no failed screens for HOWI or MIWI, these sites have no pollutants of interest based on the risk screening process. The short sampling duration at each site also prevents annual average concentrations (and at least some quarterly average concentrations) for hexavalent chromium to be calculated. In order to facilitate a review of the data collected at these sites in 2013, a few statistical calculations are provided in the section that follows. Site-specific statistical summaries for HOWI and MIWI are also provided in Appendix O. The concentration comparison and trend analysis were not performed for these sites.

30.4.1 2013 Concentration Averages

Quarterly concentration averages were calculated for hexavalent chromium for the Wisconsin sites, as described above, where applicable. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average*, which includes all measured detections and substituted zeros for non-detects for the entire year of sampling, could not be calculated for these sites as sampling at HOWI and MIWI was discontinued mid-year. Quarterly average concentrations, where applicable, were calculated for HOWI and MIWI and are presented in Table 30-5. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 30-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Wisconsin Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m ³)	2nd Quarter Average (ng/m ³)	3rd Quarter Average (ng/m ³)	4th Quarter Average (ng/m ³)	Annual Average (ng/m ³)
Horicon, Wisconsin - HOWI						
Hexavalent Chromium	4/30	0.0013 ± 0.0018	0.0022 ± 0.0031	NA	NA	NA
Milwaukee, Wisconsin - MIWI						
Hexavalent Chromium	8/11	0.0160 ± 0.0093	NA	NA	NA	NA

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations from Table 30-5 include the following:

- Concentrations of hexavalent chromium measured at HOWI range from 0.0088 ng/m³ to 0.019 ng/m³ (as well as 26 non-detects).
- For both quarterly average concentrations that could be calculated for HOWI, the confidence interval is greater than the average itself. This is due to the relatively high number of non-detects. Only two measured detections, and thus 13 zeros substituted for non-detects, are incorporated into each quarterly average concentration for HOWI.
- Concentrations of hexavalent chromium measured at MIWI range from 0.0033 ng/m³ to 0.0405 ng/m³ (as well as three non-detects). These measurements represent a

decrease in the magnitude of the measurements compared to those measured during the first 9 months of sampling in 2012.

- The first quarter average concentration for MWIW represents the entire range of measurements collected at MIWI prior to the conclusion of sampling and thus, is both a quarterly average and the average for the period of sampling in 2013.

30.5 Additional Risk-Based Screening Evaluations

In order to characterize risk at participating monitoring sites, additional risk-based screening evaluations were conducted. Because there were no pollutants of interest identified for the Wisconsin sites and because annual average concentrations could not be calculated for the pollutant sampled for at these sites, cancer risk and noncancer hazard approximations, as described in Section 3.4.3.3, were not calculated. The risk-based emissions assessment described in Section 3.4.3.4 was still conducted, at least in part, as the emissions can be reviewed independent of concentrations measured.

30.5.1 Risk-Based Emissions Assessment

This section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively, and is intended to help policy-makers prioritize their air monitoring activities. Table 30-6 presents the 10 pollutants with the highest emissions from the 2011 NEI (version 2) that have cancer toxicity factors. Table 30-6 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.4.3.4. The emissions and toxicity-weighted emissions are shown in descending order in Table 30-6. Table 30-7 presents similar information, but is limited to those pollutants with noncancer toxicity factors. Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. A more in-depth discussion of this analysis is provided in Section 3.4.3.4.

Table 30-6. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Wisconsin Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Horicon, Wisconsin (Dodge County) - HOWI					
Benzene	69.92	Formaldehyde	5.95E-04		
Formaldehyde	45.75	Benzene	5.45E-04		
Acetaldehyde	30.32	1,3-Butadiene	2.50E-04		
Ethylbenzene	24.46	Naphthalene	1.78E-04		
1,3-Butadiene	8.32	POM, Group 2b	1.19E-04		
Naphthalene	5.22	POM, Group 5a	8.55E-05		
POM, Group 2b	1.35	POM, Group 2d	7.54E-05		
POM, Group 2d	0.86	Acetaldehyde	6.67E-05		
Trichloroethylene	0.85	Ethylbenzene	6.11E-05		
POM, Group 6	0.10	Hexavalent Chromium	4.89E-05		
Milwaukee, Wisconsin (Milwaukee County) - MIWI					
Benzene	235.46	Hexavalent Chromium	2.90E-03		
Formaldehyde	183.24	Formaldehyde	2.38E-03		
Ethylbenzene	146.27	Benzene	1.84E-03		
Acetaldehyde	111.84	1,3-Butadiene	1.13E-03		
1,3-Butadiene	37.60	Nickel, PM	1.07E-03		
Naphthalene	19.92	Naphthalene	6.77E-04		
Dichloromethane	14.89	Arsenic, PM	5.12E-04		
POM, Group 2b	4.76	POM, Group 2b	4.19E-04		
POM, Group 2d	3.34	Ethylbenzene	3.66E-04		
Trichloroethylene	2.86	POM, Group 2d	2.94E-04		

Table 30-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Wisconsin Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Hazard Approximation (HQ)
Horicon, Wisconsin (Dodge County) - HOWI					
Toluene	331.94	Acrolein	136,980.59		
Xylenes	115.87	Formaldehyde	4,668.80		
Hexane	74.18	1,3-Butadiene	4,159.39		
Benzene	69.92	Acetaldehyde	3,368.91		
Methanol	50.62	Cyanide Compounds, gas	2,508.26		
Formaldehyde	45.75	Benzene	2,330.83		
Acetaldehyde	30.32	Naphthalene	1,741.51		
Ethylbenzene	24.46	Xylenes	1,158.69		
Ethylene glycol	21.53	Lead, PM	1,151.06		
Hydrochloric acid	18.25	Hydrochloric acid	912.47		
Milwaukee, Wisconsin (Milwaukee County) - MIWI					
Toluene	1,012.99	Acrolein	621,919.36		
Methanol	644.26	Nickel, PM	24,765.94		
Xylenes	582.77	Hydrochloric acid	22,589.06		
Hexane	577.45	1,3-Butadiene	18,798.74		
Hydrochloric acid	451.78	Formaldehyde	18,698.32		
Ethylene glycol	338.20	Acetaldehyde	12,426.36		
Benzene	235.46	Manganese, PM	10,644.44		
Formaldehyde	183.24	Hydrofluoric acid	9,117.92		
Ethylbenzene	146.27	Arsenic, PM	7,940.23		
Hydrofluoric acid	127.65	Benzene	7,848.51		

Observations from Table 30-6 include the following:

- Benzene and formaldehyde are the highest emitted pollutants with cancer UREs in both Dodge and Milwaukee Counties, although the emissions are higher in Milwaukee County.
- Formaldehyde is the pollutant with the highest toxicity-weighted emissions (of the pollutants with cancer UREs), followed by benzene and 1,3-butadiene, for Dodge County. Hexavalent chromium is the pollutant with the highest toxicity-weighted emissions for Milwaukee County, followed by formaldehyde and benzene.
- Eight of the highest emitted pollutants in Dodge County also have the highest toxicity-weighted emissions. Seven of the highest emitted pollutants in Milwaukee County also have the highest toxicity-weighted emissions.
- Hexavalent chromium, which is the only pollutant sampled for at HOWI and MIWI, has the highest toxicity-weighted emissions for Milwaukee County and the 10th highest toxicity-weighted emissions for Dodge County, but is not among the highest emitted for either county. Hexavalent chromium emissions in Dodge County rank 19th and in Milwaukee County rank 16th.

Observations from Table 30-7 include the following:

- Toluene is the highest emitted pollutant with a noncancer RfC in both counties. Xylenes and hexane follow toluene for Dodge County while methanol and xylenes follow toluene for Milwaukee County. The emissions are considerably higher for Milwaukee County than Dodge County.
- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties is acrolein. Formaldehyde and 1,3-butadiene follow acrolein for Dodge County while nickel and hydrochloric acid follow acrolein for Milwaukee County.
- Five of the highest emitted pollutants in Dodge County also have the highest toxicity-weighted emissions. Four of the highest emitted pollutants in Milwaukee County also have the highest toxicity-weighted emissions.
- Hexavalent chromium does not appear among the pollutants with the highest emissions or toxicity-weighted emissions for either county (among pollutants with noncancer RfCs).

30.6 Summary of the 2013 Monitoring Data for HOWI and MIWI

Results from several of the data treatments described in this section include the following:

- ❖ *Hexavalent chromium was the only pollutant sampled for at HOWI and MIWI, although sampling was discontinued in March at MIWI and in June at HOWI.*
- ❖ *Hexavalent chromium was detected in only four of the 30 valid samples collected at HOWI; hexavalent chromium was detected in eight of the 11 valid samples collected at MIWI.*
- ❖ *None of the concentrations of hexavalent chromium measured at either site failed screens.*

31.0 Data Quality

This section discusses the data quality of the ambient air measurements that constitute the 2013 NMP dataset. Each monitoring program under the NMP has its own specific Data Quality Objectives (DQOs) which have been established and approved by EPA, consistent with the specific data use needs of the individual monitoring program. Because the DQOs are program-specific and the ERG laboratory is contracted to perform services for a subset of the overall program participants, attainment of the individual program DQO(s) is not assessed in this report. This section establishes data quality through the assessment of Data Quality Indicators (DQI) in the form of MQOs specific to the program elements conducted by the ERG laboratory. MQOs are designed to control and evaluate the various phases of the measurement process (sampling, preparation, analysis, etc.) to ensure that the total measurement quality meets the overall program data quality needs. In accordance with ERG's EPA-approved QAPP (ERG, 2013), the following MQOs were assessed: completeness, precision, and accuracy (also called bias).

The quality assessments presented in this section show that the 2013 monitoring data are of a known and high quality, consistent with the intended data use. The overall method-specific completeness was greater than 90 percent for each method. The method precision for collocated and duplicate analyses met the precision MQO of 15 percent Coefficient of Variation (CV) for all methods except ASTM D7614 for hexavalent chromium measurement. The analytical precision for replicate analyses also met the precision MQO of 15 percent CV, with all method less than 10 percent. Audit samples show that ERG is meeting the accuracy requirements of the NATTS TAD (EPA, 2009b). These data quality indicators are discussed in further detail in the following sections.

31.1 Completeness

Completeness refers to the number of valid samples successfully collected and analyzed compared to the number of total samples scheduled to be collected and analyzed. The MQO for completeness based on the EPA-approved QAPP specifies that at least 85 percent of samples collected at a given monitoring site must be analyzed successfully to be considered sufficient for data trends analysis (ERG, 2013). The MQO of 85 percent completeness was met by all but three of 143 site-method combinations. Completeness statistics are presented and discussed more thoroughly in Section 2.4.

31.2 Method Precision

Precision defines the level of agreement between independent measurements performed according to identical protocols and procedures. *Method precision*, which includes *sampling and analytical precision*, quantifies random errors associated with collecting ambient air samples and analyzing the samples in the laboratory. Method precision is evaluated by comparing concentrations measured in duplicate or collocated samples. A *duplicate* sample is a sample collected simultaneously with a primary sample through a common inlet probe such that the same air parcel is being sampled. This simultaneous collection is typically achieved by teeing the line from the sampler to two canisters (or other sampling media) and doubling the flow rate applied to achieve integration over the 24-hour collection period. *Collocated* samples are samples collected simultaneously through separate inlet probes, regardless of sampler set-up (i.e., either two separate sampling systems or a single sampling system with multiple inlets). Because the samples are not collected using a common inlet, the system is sampling potentially different air parcels. The overarching difference between the two sample types is whether or not the potential for non-homogeneity of the air parcel is being considered as part of the precision calculation. Duplicate samples provide an indication of “intra-system” variability while collocated samples provide an indication of “inter-system” variability, of which the non-homogeneity of the air parcels sampled factors into the level of precision measured.

During the 2013 sampling year, duplicate and collocated samples were collected on at least 10 percent of the scheduled sample days, as outlined in the EPA-approved QAPP. This provides a minimum of six pairs of either duplicate or collocated samples per site and method. For the VOC, SNMOC, and carbonyl compound methods, samples may be duplicate or collocated. For PAHs/Phenols, metals, and hexavalent chromium, only collocated samples may be collected due to limitations of the sampling media/instrumentation. For each method, these duplicate or collocated samples were then analyzed in replicate. *Replicate measurements* are repeated analyses performed on a duplicate or collocated pair of samples and are discussed in greater detail in Section 31.3. In the event duplicate or collocated events were not possible at a given monitoring site, additional replicate samples were run on individual samples to provide an indication of analytical precision, and is discussed further in Section 31.3.

Method precision is calculated by comparing the concentrations of the duplicates/collocates for each pollutant. The CV for duplicate or collocated samples was calculated for each pollutant and each site. The following approach was employed to estimate how closely the collected and analyzed samples agree with one another:

Coefficient of Variation (CV) provides a relative measure of data dispersion compared to the mean. CV can be calculated two ways. The first, which expresses the CV as a ratio of the standard deviation and the mean, is used for a single variable. The second, which is provided below, is ideal when comparing paired values, such as a primary concentration and a duplicate concentration. A coefficient of variation of 1 percent would indicate that the analytical results could vary slightly due to sampling error, while a variation of 50 percent means that the results are more imprecise.

$$CV = 100 \times \sqrt{\frac{\sum_{i=1}^n \left[\frac{(p-r)}{0.5 \times (p+r)} \right]^2}{2n}}$$

Where:

- p = the primary result from a duplicate or collocated pair;
- r = the secondary result from a duplicate or collocated pair;
- n = the number of valid data pairs (the 2 adjusts for the fact that there are two values with error).

Coefficients of variation were based on every pair of duplicate or collocated samples collected during the program year. However, only measurements at or above the MDL were used in these calculations. Thus, the number of pairs included in the calculations varies significantly from pollutant to pollutant. This is a change in procedure compared to NMP reports prior to 2010, where comparison to the MDL was not considered and 1/2 MDL was substituted for non-detects. To make an overall estimate of method precision, program-level average CVs were calculated as follows:

- A site-specific CV was calculated for each pollutant, per the equation above.
- A pollutant-specific average CV was calculated for each method.
- A method-specific average CV was calculated and compared to the precision MQO.

Table 31-1 presents the 2013 NMP method precision for VOCs, SNMOCs, carbonyl compounds, PAHs, metals, and hexavalent chromium, presented as the average CV (expressed as a percentage). With one exception, each analytical method met the program MQO of 15 percent CV for precision. Only hexavalent chromium results did not meet the MQO of 15 percent. This table also includes the number of pairs that were included in the calculation of the method precision. The total number of pairs for each method is also included in Table 31-1 to provide an indication of the effect that excluding those with concentrations less than the MDL has on the population of pairs in the dataset. For some methods, such as TO-11A for carbonyl compounds, the difference is small; for others, such as TO-15 for VOCs, the difference is relatively large.

Table 31-1. Method Precision by Analytical Method

Method/Pollutant Group	Average Coefficient of Variation (%)	Number of Pairs Included in the Calculation	Total Number of Pairs Without the > MDL exclusion
VOC (TO-15)	10.07	3,953	5,006
SNMOC	9.95	436	536
Carbonyl Compounds (TO-11A)	7.12	1,699	1,701
PAHs (TO-13)	10.28	379	470
Metals Analysis (Method IO-3.5/FEM)	13.37	1,585	2,072
Hexavalent Chromium (ASTM D7614)	20.51	27	28
MQO	15.00 percent CV		

Tables 31-2 through 31-7 present method precision for VOCs, SNMOCs, carbonyl compounds, PAHs, metals, and hexavalent chromium, respectively, as the CV per pollutant per site and the average CV per site, per pollutant, and per method. Also included in these tables is the number of duplicate and/or collocated pairs included in the CV calculations. For methods where duplicate or collocated samples are both possible, the type of sample collected at each site is identified and the average CV based on sample type is also provided. CVs exceeding the 15 percent MQO are bolded in each table. The CVs that exceed the program MQO for precision are often driven by relatively low concentrations, even though they are greater than the MDL, as these may result in relatively large CVs.

31.2.1 VOC Method Precision

Table 31-2 presents the method precision for all duplicate and collocated VOC samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across all VOCs listed. The individual method precision results exhibit low- to high-level variability, where the CV ranges from 0 percent (a few pollutants for several sites) to 82.50 percent (*p*-dichlorobenzene for TMOK). The CV for *p*-dichlorobenzene for TMOK is based on a single pair of samples greater than the MDL. The number of sites for which a given pollutant has a CV greater than 15 percent varies, from none (30 pollutants) to greater than 20 (two pollutants). Dichloromethane (20) and methyl isobutyl ketone (21) have the highest number of sites with average CVs greater than 15 percent.

The pollutant-specific average CV, as shown in orange in Table 31-2, ranges from 0 percent (bromoform, 1,1,2,2-tetrachloroethane, and 1,1,1-trichloroethane) to 35.71 percent (bromodichloromethane). For the three pollutants with an average CV of 0 percent, the precision is based on a single pair of measurements greater than the MDL. For bromodichloromethane, the precision is based on five pairs of measurements collected at a single site (NBIL). The site-specific average CV, as shown in green in Table 31-2, ranges from 6.33 percent (ROIL) to 13.95 percent (TMOK). None of the sites have a site-specific average CV greater than 15 percent. The overall average method precision for VOCs is 10.07 percent. Note that the results for acrolein, acetonitrile, acrylonitrile, and carbon disulfide were excluded from the precision calculations due to the issues described in Section 3.2.

Sites at which duplicate samples were collected are highlighted in blue in Table 31-2 while sites at which collocated samples were collected are highlighted in purple. Collocated VOC samples were collected at only three of the sites shown in Table 31-2 (BURVT, PXSS, and TVKY); the remainder collected duplicate VOC samples. The average CV for sites that collected duplicate samples was calculated and is shown in Table 31-2 in blue while the average CV for sites collecting collocated samples is shown in purple. The average CV for both precision types meets the MQO of 15 percent, with the variability associated with collocated samples (11.83 percent) slightly greater than the variability associated with duplicate samples (10.27 percent).

**Table 31-2. VOC Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant**

Pollutant	ADOK	ANAK	BTUT	BURVT	CHNJ	CSNJ	DEMI	ELNJ
Acetylene	4.13	7.46	4.08	7.24	8.69	6.37	8.32	7.58
<i>tert</i> -Amyl Methyl Ether	--	--	--	--	--	--	--	--
Benzene	7.69	7.03	18.35	11.93	7.87	3.55	28.12	1.63
Bromochloromethane	--	--	--	--	--	--	--	--
Bromodichloromethane	--	--	--	--	--	--	--	--
Bromoform	--	--	--	--	--	--	--	--
Bromomethane	--	5.66	5.24	15.65	16.13	20.67	4.88	19.37
1,3-Butadiene	6.02	5.04	3.40	6.79	36.15	4.10	12.09	4.35
Carbon Tetrachloride	8.37	10.12	3.64	7.49	7.46	9.75	8.91	7.82
Chlorobenzene	--	--	--	--	--	--	--	--
Chloroethane	--	--	--	33.36	17.46	25.38	--	4.56
Chloroform	--	4.36	2.54	8.27	7.60	3.43	48.97	2.51
Chloromethane	0.66	2.24	2.89	7.34	8.08	4.01	6.04	5.14
Chloroprene	--	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--	--	--
1,2-Dibromoethane	--	--	--	--	--	--	--	--
<i>m</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>o</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>p</i> -Dichlorobenzene	--	2.24	--	--	--	--	--	--
Dichlorodifluoromethane	4.14	2.42	2.48	4.94	8.19	7.59	5.10	3.40
1,1-Dichloroethane	--	--	--	--	--	--	--	--
1,2-Dichloroethane	7.62	2.23	1.81	12.69	12.14	10.09	7.62	6.16
1,1-Dichloroethene	--	--	0.00	--	--	--	--	--
<i>cis</i> -1,2-Dichloroethylene	--	--	--	--	--	--	--	--
<i>trans</i> -1,2-Dichloroethylene	--	--	--	9.05	--	--	--	--
Dichloromethane	36.68	25.45	18.27	30.56	7.99	7.90	20.99	32.26
1,2-Dichloropropane	--	--	--	--	--	--	--	--
<i>cis</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--
<i>trans</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--
Dichlorotetrafluoroethane	6.56	4.46	3.85	6.03	10.14	2.73	4.77	6.43
Ethyl Acrylate	--	--	--	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-2. VOC Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)**

Pollutant	ADOK	ANAK	BTUT	BURVT	CHNJ	CSNJ	DEMI	ELNJ
Ethyl <i>tert</i> -Butyl Ether	--	--	5.25	--	41.49	33.71	--	4.87
Ethylbenzene	10.79	10.70	3.26	14.55	17.79	4.20	8.93	2.76
Hexachloro-1,3-butadiene	--	--	--	--	--	--	--	--
Methyl Isobutyl Ketone	48.87	32.34	44.27	30.92	18.65	15.05	12.21	6.41
Methyl Methacrylate	--	--	--	--	--	12.53	--	11.85
Methyl <i>tert</i> -Butyl Ether	--	--	11.70	--	18.55	3.66	--	24.72
<i>n</i> -Octane	8.26	8.29	4.88	15.87	9.38	4.45	10.69	6.34
Propylene	38.75	17.69	29.64	19.17	13.14	7.19	7.15	4.62
Styrene	7.26	10.94	4.71	8.31	2.11	10.11	21.59	11.14
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	0.00
Tetrachloroethylene	--	11.88	--	5.12	11.59	7.46	15.01	2.99
Toluene	9.39	9.48	6.84	10.82	2.53	7.76	5.04	1.62
1,2,4-Trichlorobenzene	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--	0.00
1,1,2-Trichloroethane	--	--	--	--	--	--	--	--
Trichloroethylene	--	--	--	9.28	--	1.30	--	22.10
Trichlorofluoromethane	4.63	2.58	2.28	4.95	7.47	6.40	3.32	2.91
Trichlorotrifluoroethane	4.60	5.20	2.67	18.65	7.89	2.15	3.18	3.23
1,2,4-Trimethylbenzene	3.28	6.18	3.78	11.35	4.85	3.04	8.86	4.44
1,3,5-Trimethylbenzene	1.75	6.07	2.04	5.79	7.76	5.34	15.72	6.07
Vinyl chloride	--	--	--	--	--	--	--	--
<i>m,p</i> -Xylene	5.25	10.25	2.50	16.94	14.34	4.83	7.48	2.94
<i>o</i> -Xylene	7.88	10.30	6.45	17.15	19.81	4.00	7.40	3.57
Average by Site	11.08	8.82	7.57	12.97	12.79	8.23	11.77	7.22
# of Pairs Collected per Site	3	6	4	27	6	5	6	6

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-2. VOC Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)**

Pollutant	GLKY	GPCO	KMMS	NBIL	NBNJ	OCOK	PXSS	ROIL
Acetylene	5.98	5.06	4.13	6.45	5.12	7.19	3.80	5.08
<i>tert</i> -Amyl Methyl Ether	--	--	--	--	--	--	--	--
Benzene	6.57	3.75	11.80	6.76	7.11	4.22	6.02	2.24
Bromochloromethane	--	--	--	--	--	--	--	--
Bromodichloromethane	--	--	--	35.71	--	--	--	--
Bromoform	--	--	--	0.00	--	--	--	--
Bromomethane	12.00	14.81	--	5.66	4.00	37.22	5.00	8.43
1,3-Butadiene	7.36	10.95	9.63	7.20	2.00	18.48	8.27	7.65
Carbon Tetrachloride	7.22	21.74	6.71	6.26	24.36	3.71	6.96	7.16
Chlorobenzene	--	--	--	--	--	--	--	--
Chloroethane	--	--	--	6.67	--	--	8.96	14.43
Chloroform	--	3.66	7.03	28.70	6.14	7.32	5.12	6.05
Chloromethane	7.36	2.60	4.50	3.04	3.56	19.10	3.07	3.39
Chloroprene	--	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	19.38	--	--	--	--
1,2-Dibromoethane	--	--	--	--	--	--	--	--
<i>m</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>o</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>p</i> -Dichlorobenzene	--	--	--	--	--	--	5.08	--
Dichlorodifluoromethane	5.25	2.94	3.27	2.55	2.46	3.79	2.57	3.52
1,1-Dichloroethane	--	--	--	--	--	--	--	--
1,2-Dichloroethane	5.86	5.92	7.26	0.00	4.24	3.26	4.16	11.33
1,1-Dichloroethene	--	--	--	--	--	--	--	--
<i>cis</i> -1,2-Dichloroethylene	--	--	--	--	--	--	--	--
<i>trans</i> -1,2-Dichloroethylene	--	--	--	--	--	--	10.10	--
Dichloromethane	58.20	19.97	13.03	15.72	16.84	36.26	38.61	24.73
1,2-Dichloropropane	--	--	--	--	--	--	--	--
<i>cis</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--
<i>trans</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--
Dichlorotetrafluoroethane	8.04	5.54	3.39	2.82	3.24	3.33	4.80	5.71
Ethyl Acrylate	--	--	--	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-2. VOC Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)**

Pollutant	GLKY	GPCO	KMMS	NBIL	NBNJ	OCOK	PXSS	ROIL
Ethyl <i>tert</i> -Butyl Ether	--	7.58	--	6.50	4.04	--	--	--
Ethylbenzene	16.61	4.65	6.68	4.49	5.84	8.39	8.29	2.89
Hexachloro-1,3-butadiene	--	--	--	--	--	--	--	--
Methyl Isobutyl Ketone	33.95	27.52	17.81	16.20	23.55	34.11	16.89	8.44
Methyl Methacrylate	--	2.95	--	3.39	--	--	13.83	--
Methyl <i>tert</i> -Butyl Ether	--	48.90	--	--	35.36	--	41.30	--
<i>n</i> -Octane	31.65	15.11	7.62	8.94	6.49	7.17	12.40	4.87
Propylene	18.57	21.87	13.98	7.43	11.18	24.16	12.66	4.19
Styrene	8.84	33.64	11.35	15.77	11.93	5.11	13.16	9.01
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	--
Tetrachloroethylene	--	3.53	2.82	22.57	4.01	4.29	8.33	4.04
Toluene	19.04	3.17	5.13	7.08	5.82	8.79	17.59	2.80
1,2,4-Trichlorobenzene	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--	--
1,1,2-Trichloroethane	--	--	--	--	--	--	--	--
Trichloroethylene	--	--	0.00	--	5.66	--	--	--
Trichlorofluoromethane	2.26	3.20	3.03	4.20	2.39	3.84	1.87	7.06
Trichlorotrifluoroethane	3.69	3.50	3.40	2.19	2.33	3.48	2.27	2.78
1,2,4-Trimethylbenzene	7.40	6.43	5.20	9.45	6.15	11.32	8.71	4.03
1,3,5-Trimethylbenzene	7.07	3.93	10.16	10.30	6.67	4.76	14.28	4.88
Vinyl chloride	--	--	5.24	4.04	--	--	--	--
<i>m,p</i> -Xylene	16.79	4.24	6.72	4.40	4.84	6.04	8.15	2.65
<i>o</i> -Xylene	11.40	4.48	6.11	5.64	4.79	8.78	8.84	0.96
Average by Site	13.69	10.80	7.04	9.02	8.15	11.42	10.38	6.33
# of Pairs Collected per Site	6	7	6	7	6	6	7	5

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-2. VOC Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)**

Pollutant	S4MO	SEWA	SPIL	SSMS	TMOK	TOOK	TROK	TVKY
Acetylene	3.52	4.88	8.16	5.49	8.55	6.22	6.13	6.82
<i>tert</i> -Amyl Methyl Ether	--	--	--	--	--	--	--	--
Benzene	8.06	3.84	6.02	3.77	4.81	4.73	6.48	15.56
Bromochloromethane	--	--	--	--	--	--	--	--
Bromodichloromethane	--	--	--	--	--	--	--	--
Bromoform	--	--	--	--	--	--	--	--
Bromomethane	5.44	--	16.86	26.44	6.80	7.45	20.40	15.85
1,3-Butadiene	13.29	5.59	6.98	10.51	9.72	8.24	20.24	8.37
Carbon Tetrachloride	2.29	4.89	5.00	2.91	26.48	4.73	7.38	7.45
Chlorobenzene	--	--	--	--	--	--	--	--
Chloroethane	--	--	--	--	--	6.73	--	14.78
Chloroform	7.23	9.57	9.74	4.04	21.06	4.74	5.26	9.45
Chloromethane	2.74	4.38	3.71	4.50	6.48	17.30	11.51	7.20
Chloroprene	--	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--	--	--
1,2-Dibromoethane	--	--	--	--	--	--	--	--
<i>m</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>o</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>p</i> -Dichlorobenzene	5.45	--	--	--	82.50	--	--	0.00
Dichlorodifluoromethane	3.24	3.17	4.17	1.85	5.93	5.33	5.59	3.97
1,1-Dichloroethane	--	--	--	--	--	--	--	4.57
1,2-Dichloroethane	8.75	11.36	7.51	6.10	0.00	3.50	5.94	8.78
1,1-Dichloroethene	--	--	--	--	--	--	--	6.98
<i>cis</i> -1,2-Dichloroethylene	--	--	--	--	--	--	--	--
<i>trans</i> -1,2-Dichloroethylene	--	--	--	--	--	--	8.27	4.37
Dichloromethane	25.23	65.60	10.35	10.47	17.31	74.85	33.77	24.98
1,2-Dichloropropane	--	--	--	--	--	--	--	--
<i>cis</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--
<i>trans</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--
Dichlorotetrafluoroethane	7.30	13.38	3.99	3.28	10.77	4.51	5.62	6.41
Ethyl Acrylate	--	--	--	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-2. VOC Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)**

Pollutant	S4MO	SEWA	SPIL	SSMS	TMOK	TOOK	TROK	TVKY
Ethyl <i>tert</i> -Butyl Ether	--	--	13.69	--	--	--	--	--
Ethylbenzene	14.55	5.56	9.65	13.05	9.03	3.91	3.24	15.39
Hexachloro-1,3-butadiene	--	--	--	--	--	--	--	--
Methyl Isobutyl Ketone	35.03	7.84	36.13	22.00	43.26	41.07	22.60	20.88
Methyl Methacrylate	--	--	--	--	--	6.90	--	--
Methyl <i>tert</i> -Butyl Ether	--	--	35.66	--	--	--	--	--
<i>n</i> -Octane	18.04	9.55	11.31	15.20	5.21	4.86	6.39	14.92
Propylene	16.23	8.90	6.28	12.44	19.42	10.24	10.99	12.74
Styrene	27.78	8.66	1.48	1.10	5.80	5.55	15.13	39.90
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	--
Tetrachloroethylene	5.04	6.39	5.22	3.82	13.34	7.26	4.64	7.78
Toluene	6.47	3.40	8.06	4.69	8.62	5.53	3.39	48.72
1,2,4-Trichlorobenzene	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--	--
1,1,2-Trichloroethane	--	--	--	--	--	--	--	2.89
Trichloroethylene	11.06	--	0.00	40.75	--	--	--	7.44
Trichlorofluoromethane	3.33	3.74	2.32	1.88	6.39	5.33	5.23	16.88
Trichlorotrifluoroethane	3.25	4.54	4.20	2.57	7.13	4.44	4.90	3.87
1,2,4-Trimethylbenzene	12.92	9.73	10.39	12.64	10.41	5.92	5.07	13.02
1,3,5-Trimethylbenzene	10.32	6.19	0.00	0.00	6.03	4.42	5.81	8.51
Vinyl chloride	--	--	--	0.00	--	--	--	4.80
<i>m,p</i> -Xylene	11.23	6.28	9.44	9.55	6.87	4.02	3.02	15.27
<i>o</i> -Xylene	11.98	5.42	10.09	11.05	6.91	4.22	5.44	17.50
Average by Site	10.76	9.26	9.13	8.85	13.95	10.08	9.30	12.38
# of Pairs Collected per Site	6	6	6	6	6	7	7	31

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-2. VOC Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)**

Pollutant	YUOK	# of Pairs	Average by Pollutant	Average for Duplicate Pairs	Average for Collocated Pairs
Acetylene	7.44	190	6.16	6.18	5.95
<i>tert</i> -Amyl Methyl Ether	--	--	--	--	--
Benzene	5.27	191	7.73	7.26	11.17
Bromochloromethane	--	--	--	--	--
Bromodichloromethane	--	5	35.71	35.71	--
Bromoform	--	1	0.00	0.00	--
Bromomethane	4.35	67	12.65	12.73	12.16
1,3-Butadiene	3.32	155	9.43	9.65	7.81
Carbon Tetrachloride	2.26	190	8.44	8.60	7.30
Chlorobenzene	--	--	--	--	--
Chloroethane	--	16	14.70	12.54	19.03
Chloroform	--	119	9.67	10.00	7.61
Chloromethane	4.09	191	5.80	5.79	5.87
Chloroprene	--	--	--	--	--
Dibromochloromethane	--	3	19.38	19.38	--
1,2-Dibromoethane	--	--	--	--	--
<i>m</i> -Dichlorobenzene	--	--	--	--	--
<i>o</i> -Dichlorobenzene	--	--	--	--	--
<i>p</i> -Dichlorobenzene	--	9	19.06	30.07	2.54
Dichlorodifluoromethane	5.12	191	4.12	4.16	3.83
1,1-Dichloroethane	--	5	4.57	--	4.57
1,2-Dichloroethane	6.73	134	6.44	6.16	8.54
1,1-Dichloroethene	--	3	3.49	0.00	6.98
<i>cis</i> -1,2-Dichloroethylene	--	--	--	--	--
<i>trans</i> -1,2-Dichloroethylene	--	7	7.95	8.27	7.84
Dichloromethane	43.59	183	28.38	27.98	31.38
1,2-Dichloropropane	--	--	--	--	--
<i>cis</i> -1,3-Dichloropropene	--	--	--	--	--
<i>trans</i> -1,3-Dichloropropene	--	--	--	--	--
Dichlorotetrafluoroethane	5.80	191	5.72	5.71	5.75
Ethyl Acrylate	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-2. VOC Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)**

Pollutant	YUOK	# of Pairs	Average by Pollutant	Average for Duplicate Pairs	Average for Collocated Pairs
Ethyl <i>tert</i> -Butyl Ether	--	26	14.64	14.64	--
Ethylbenzene	9.23	179	8.58	8.01	12.74
Hexachloro-1,3-butadiene	--	--	--	--	--
Methyl Isobutyl Ketone	19.23	127	25.41	25.75	22.90
Methyl Methacrylate	--	9	8.57	7.52	13.83
Methyl <i>tert</i> -Butyl Ether	--	23	27.48	25.51	41.30
<i>n</i> -Octane	9.43	171	10.29	9.73	14.40
Propylene	7.41	191	14.24	14.16	14.86
Styrene	--	96	12.10	10.91	20.46
1,1,2,2-Tetrachloroethane	--	1	0.00	0.00	--
Tetrachloroethylene	--	75	7.48	7.55	7.08
Toluene	1.06	191	8.51	6.17	25.71
1,2,4-Trichlorobenzene	--	--	--	--	--
1,1,1-Trichloroethane	--	1	0.00	0.00	--
1,1,2-Trichloroethane	--	2	2.89	--	2.89
Trichloroethylene	--	11	10.84	11.55	8.36
Trichlorofluoromethane	5.31	191	4.51	4.05	7.90
Trichlorotrifluoroethane	2.99	191	4.36	3.83	8.26
1,2,4-Trimethylbenzene	8.93	158	7.74	7.29	11.03
1,3,5-Trimethylbenzene	0.00	83	6.16	5.70	9.53
Vinyl chloride	--	17	3.52	3.09	4.80
<i>m,p</i> -Xylene	6.70	182	7.63	6.83	13.45
<i>o</i> -Xylene	11.84	177	8.48	7.66	14.50
Average by Site	8.10	3,953	10.07	10.27	11.83
# of Pairs Collected per Site	3				

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

31.2.2 SNMOC Method Precision

The SNMOC method precision for duplicate samples is presented in Table 31-3 as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across all SNMOCs listed. The individual method precision results from duplicate samples exhibit low- to mid-level variability among the pollutants and sites, ranging from a CV of 0.24 percent (1,3-butadiene for BTUT) to 45.68 percent (isoprene for NBIL). The CVs for 29 pollutants are less than 15 percent for both sites; conversely, there are only four pollutants listed where the CV is greater than 15 percent for both sites: 2-methylhexane, 1-pentene, 2,3,4-trimethylpentane, and sum of unknowns.

The pollutant-specific average CV, as shown in orange in Table 31-3, ranges from 0.24 percent (1,3-butadiene) to 35.18 percent (2-methylhexane). The site-specific average CV, as shown in green in Table 31-3, ranges from 9.94 percent (BTUT) to 10.54 percent (NBIL); these are the only sites at which duplicate SNMOC samples were collected. No colocated SNMOC samples were collected during the 2013 program year. The overall average method precision for SNMOCs is 9.95 percent. Note that the results for TNMOC were not included in the precision calculations.

Table 31-3. SNMOC Method Precision: Coefficient of Variation Based on Duplicate Samples by Site and Pollutant

Pollutant	<i>BTUT</i>	<i>NBIL</i>	# of Pairs	Average by Pollutant
Acetylene	5.31	7.84	11	6.57
Benzene	18.74	6.35	8	12.55
1,3-Butadiene	0.24	--	1	0.24
<i>n</i> -Butane	0.37	4.06	11	2.22
1-Butene	--	--	--	--
<i>cis</i> -2-Butene	3.16	--	3	3.16
<i>trans</i> -2-Butene	18.22	--	4	18.22
Cyclohexane	4.86	5.80	10	5.33

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

BOLD ITALICS = EPA-designated NATTS Site

Table 31-3. SNMOC Method Precision: Coefficient of Variation Based on Duplicate Samples by Site and Pollutant (Continued)

Pollutant	<i>BTUT</i>	<i>NBIL</i>	# of Pairs	Average by Pollutant
Cyclopentane	1.65	16.28	6	8.97
Cyclopentene	--	--	--	--
<i>n</i> -Decane	4.04	11.88	7	7.96
1-Decene	--	--	--	--
<i>m</i> -Diethylbenzene	--	--	--	--
<i>p</i> -Diethylbenzene	--	--	--	--
2,2-Dimethylbutane	2.92	17.41	8	10.17
2,3-Dimethylbutane	2.54	4.35	9	3.44
2,3-Dimethylpentane	3.20	5.16	7	4.18
2,4-Dimethylpentane	4.67	1.97	3	3.32
<i>n</i> -Dodecane	13.95	18.30	4	16.13
1-Dodecene	--	--	--	--
Ethane	0.76	15.56	11	8.16
2-Ethyl-1-butene	--	--	--	--
Ethylbenzene	16.55	10.77	10	13.66
Ethylene	16.38	5.85	11	11.11
<i>m</i> -Ethyltoluene	8.86	8.23	6	8.54
<i>o</i> -Ethyltoluene	1.73	7.24	4	4.49
<i>p</i> -Ethyltoluene	1.23	15.20	5	8.21
<i>n</i> -Heptane	4.37	6.48	10	5.42
1-Heptene	--	--	--	--
<i>n</i> -Hexane	1.75	5.77	10	3.76
1-Hexene	--	--	--	--
<i>cis</i> -2-Hexene	--	--	--	--
<i>trans</i> -2-Hexene	--	--	--	--
Isobutane	1.09	4.85	11	2.97
Isobutene/1-Butene	--	--	--	--
Isobutylene	--	18.78	1	18.78
Isopentane	16.32	13.45	5	14.88
Isoprene	6.08	45.68	7	25.88
Isopropylbenzene	--	0.46	1	0.46
2-Methyl-1-butene	1.40	--	1	1.40
3-Methyl-1-butene	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

BOLD ITALICS = EPA-designated NATTS Site

Table 31-3. SNMOC Method Precision: Coefficient of Variation Based on Duplicate Samples by Site and Pollutant (Continued)

Pollutant	<i>BTUT</i>	<i>NBIL</i>	# of Pairs	Average by Pollutant
2-Methyl-1-pentene	--	--	--	--
4-Methyl-1-pentene	--	--	--	--
2-Methyl-2-butene	0.98	4.58	2	2.78
Methylcyclohexane	1.67	7.37	8	4.52
Methylcyclopentane	5.71	4.41	10	5.06
2-Methylheptane	3.21	--	3	3.21
3-Methylheptane	7.18	2.22	4	4.70
2-Methylhexane	41.31	29.05	11	35.18
3-Methylhexane	3.85	3.02	7	3.43
2-Methylpentane	31.81	7.83	11	19.82
3-Methylpentane	11.96	4.59	10	8.28
<i>n</i> -Nonane	19.86	14.19	9	17.03
1-Nonene	--	8.73	2	8.73
<i>n</i> -Octane	10.44	8.63	8	9.53
1-Octene	14.10	7.86	6	10.98
<i>n</i> -Pentane	8.45	37.04	11	22.75
1-Pentene	17.58	17.28	6	17.43
<i>cis</i> -2-Pentene	--	--	--	--
<i>trans</i> -2-Pentene	3.21	--	2	3.21
<i>a</i> -Pinene	3.06	3.37	6	3.21
<i>b</i> -Pinene	--	--	--	--
Propane	0.43	4.98	11	2.70
<i>n</i> -Propylbenzene	7.88	9.14	5	8.51
Propylene	27.00	12.56	11	19.78
Propyne	--	--	--	--
Styrene	--	9.48	1	9.48
Toluene	8.13	3.52	11	5.82
<i>n</i> -Tridecane	5.99	27.88	3	16.93
1-Tridecene	--	--	--	--
1,2,3-Trimethylbenzene	30.46	8.98	6	19.72
1,2,4-Trimethylbenzene	17.91	7.46	10	12.69
1,3,5-Trimethylbenzene	11.42	5.50	5	8.46

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

BOLD ITALICS = EPA-designated NATTS Site

Table 31-3. SNMOC Method Precision: Coefficient of Variation Based on Duplicate Samples by Site and Pollutant (Continued)

Pollutant	<i>BTUT</i>	<i>NBIL</i>	# of Pairs	Average by Pollutant
2,2,3-Trimethylpentane	17.30	7.25	3	12.28
2,2,4-Trimethylpentane	10.66	3.90	10	7.28
2,3,4-Trimethylpentane	29.77	15.07	10	22.42
<i>n</i> -Undecane	4.71	12.59	7	8.65
1-Undecene	--	--	--	--
<i>m</i> -Xylene/ <i>p</i> -Xylene	5.05	4.93	11	4.99
<i>o</i> -Xylene	8.16	5.03	9	6.60
SNMOC (Sum of Knowns)	20.35	9.03	11	14.69
Sum of Unknowns	26.71	25.21	11	25.96
Average by Site	9.94	10.54	436	9.95
# of Pairs Collected per Site	4	7		

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

BOLD ITALICS = EPA-designated NATTS Site

31.2.3 Carbonyl Compound Method Precision

Table 31-4 presents the method precision for duplicate and collocated carbonyl compound samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across all carbonyl compounds listed. The duplicate and collocated sample results exhibit low- to mid-level variability, ranging from a CV of 0.57 percent (acetaldehyde for TOOK) to 47.47 percent (2-butanone for SYFL). The number of sites for which a given pollutant has a CV greater than 15 percent varies from none (five pollutants) to seven (2-butanone).

The pollutant-specific average CV, as shown in orange in Table 31-4, ranges from 3.50 percent (acetaldehyde) to 10.31 percent (hexaldehyde). The site-specific average CV, as shown in green in Table 31-4, ranges from 2.53 percent (TOOK) to 13.55 percent (SKFL). None of the sites collecting duplicate or collocated carbonyl compound samples have average CVs greater than 15 percent. The overall average method precision is 7.12 percent for carbonyl compounds.

Sites at which duplicate samples were collected are highlighted in blue in Table 31-4 while sites at which collocated samples were collected are highlighted in purple. Collocated carbonyl compound samples were collected at only three of the sites shown in Table 31-4 (DEMI, INDEM, and PXSS); the remainder collected duplicate samples. The average CV for sites that collected duplicate samples was calculated and is shown in Table 31-4 in blue while the average CV for sites collecting collocated samples is shown in purple. The average CV for both precision types meets the MQO of 15 percent, with the variability associated with collocated samples (9.64 percent) slightly greater than the variability associated with duplicate samples (6.79 percent).

**Table 31-4. Carbonyl Compound Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant**

Pollutant	ADOK	AZFL	BTUT	CHNJ	CSNJ	DEMI	ELNJ	GLKY
Acetaldehyde	1.56	4.78	3.83	1.32	4.19	6.84	1.50	1.09
Acetone	1.29	14.59	1.98	6.34	15.18	7.55	26.30	1.82
Benzaldehyde	2.47	10.34	6.59	5.75	4.99	11.56	4.68	8.98
2-Butanone	1.77	16.39	0.83	7.65	15.29	5.49	15.05	2.89
Butyraldehyde	3.92	9.33	5.12	5.04	5.37	13.95	4.39	3.57
Crotonaldehyde	1.48	6.65	4.74	5.09	5.43	10.60	4.20	8.39
2,5-Dimethylbenzaldehyde	--	--	--	--	--	--	--	--
Formaldehyde	1.99	5.10	3.91	2.51	4.27	8.94	2.74	2.33
Hexaldehyde	7.28	6.92	4.65	8.40	3.80	8.78	3.29	14.31
Isovaleraldehyde	--	--	--	--	--	--	--	--
Propionaldehyde	2.59	5.78	4.73	2.57	5.78	19.00	1.47	3.01
Tolualdehydes	4.52	7.13	9.43	8.57	7.19	11.54	5.26	8.55
Valeraldehyde	5.97	7.12	5.67	5.65	6.54	14.88	2.89	9.16
Average by Site	3.17	8.56	4.68	5.35	7.09	10.83	6.52	5.83
# of Pairs Collected per Site	3	6	4	6	6	7	6	6

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-4. Carbonyl Compound Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)**

Pollutant	GPCO	INDEM	NBIL	NBNJ	OCOK	ORFL	PXSS	ROIL
Acetaldehyde	10.12	9.45	1.36	2.76	1.42	1.69	6.31	3.65
Acetone	3.44	7.01	2.79	6.12	3.53	20.17	5.36	11.48
Benzaldehyde	23.93	8.20	5.89	6.86	5.60	8.26	4.70	7.26
2-Butanone	7.50	14.19	4.79	6.70	6.28	30.01	16.44	6.30
Butyraldehyde	11.95	10.81	5.37	4.61	1.78	8.40	15.49	6.35
Crotonaldehyde	3.32	7.11	5.74	3.40	2.08	2.36	6.84	5.16
2,5-Dimethylbenzaldehyde	--	--	--	--	--	--	--	--
Formaldehyde	11.94	9.46	1.79	3.99	1.41	2.49	9.59	1.50
Hexaldehyde	44.99	6.58	2.51	8.78	8.51	9.52	12.42	6.22
Isovaleraldehyde	--	--	--	--	--	--	--	--
Propionaldehyde	8.11	9.34	2.64	5.27	1.67	8.63	11.53	3.21
Tolualdehydes	19.92	3.94	8.01	3.11	3.67	21.29	10.24	14.30
Valeraldehyde	2.98	6.76	5.00	6.31	1.73	11.02	7.25	14.11
Average by Site	13.47	8.44	4.17	5.27	3.42	11.26	9.65	7.23
# of Pairs Collected per Site	4	11	7	6	6	7	6	6

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-4. Carbonyl Compound Method Precision: Coefficient of Variation
Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)**

Pollutant	<i>S4MO</i>	<i>SEWA</i>	<i>SKFL</i>	<i>SPIL</i>	<i>SYFL</i>	<i>TMOK</i>	<i>TOOK</i>	<i>TROK</i>
Acetaldehyde	3.13	1.87	3.44	8.36	4.37	0.90	0.57	1.08
Acetone	6.49	1.02	18.36	8.21	11.11	6.56	2.18	1.66
Benzaldehyde	7.42	10.05	10.07	8.21	4.85	2.64	7.19	5.05
2-Butanone	5.91	3.84	24.07	7.92	47.47	3.23	1.14	2.25
Butyraldehyde	3.16	3.11	14.26	9.58	21.16	2.41	1.41	3.26
Crotonaldehyde	3.61	6.26	4.57	6.04	7.76	4.24	1.12	1.71
2,5-Dimethylbenzaldehyde	--	--	--	--	--	--	--	--
Formaldehyde	3.81	5.71	14.93	9.64	3.22	0.71	1.17	2.26
Hexaldehyde	7.48	5.80	21.21	36.21	11.34	4.50	4.53	6.29
Isovaleraldehyde	--	--	--	--	--	--	--	--
Propionaldehyde	5.84	4.96	4.31	10.05	4.27	2.58	1.44	2.06
Tolualdehydes	14.41	7.98	14.48	13.65	6.66	4.22	5.97	5.52
Valeraldehyde	5.73	7.73	19.39	19.81	7.86	2.27	1.11	5.53
Average by Site	6.09	5.30	13.55	12.52	11.82	3.11	2.53	3.33
# of Pairs Collected per Site	6	6	6	5	6	6	6	7

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

Table 31-4. Carbonyl Compound Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	WPIN	YUOK	# of Pairs	Average by Pollutant	Average for Duplicate Pairs	Average for Collocated Pairs
Acetaldehyde	4.72	0.75	158	3.50	2.98	7.53
Acetone	13.90	3.85	158	8.01	8.19	6.64
Benzaldehyde	7.97	6.77	158	7.55	7.47	8.16
2-Butanone	10.62	3.73	158	10.30	10.07	12.04
Butyraldehyde	6.99	2.06	158	7.03	6.20	13.42
Crotonaldehyde	8.93	1.77	158	4.95	4.52	8.19
2,5-Dimethylbenzaldehyde	--	--	--	--	--	--
Formaldehyde	5.18	0.68	158	4.66	4.06	9.33
Hexaldehyde	6.90	6.80	156	10.31	10.44	9.26
Isovaleraldehyde	--	--	--	--	--	--
Propionaldehyde	7.18	1.48	158	5.37	4.33	13.29
Tolualdehydes	9.97	9.76	128	9.20	9.29	8.57
Valeraldehyde	7.95	3.84	151	7.47	7.19	9.63
Average by Site	8.21	3.77	1,699	7.12	6.79	9.64
# of Pairs Collected per Site	9	4				

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples.

BOLD ITALICS = EPA-designated NATTS Site

31.2.4 PAH Method Precision

The method precision results for collocated PAH samples are shown in Table 31-5 as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the PAHs listed. All samples evaluated in this section are collocated samples. Collocated systems were the responsibility of the participating agency for sites sampling PAHs. Thus, collocated samples were not collected at most PAH sites because few sites had collocated samplers. Therefore, the method precision for PAHs is based on data from five sites for 2013. The results from collocated samples exhibit low- to high-level variability, ranging from a CV of 0.78 percent (benzo(a)anthracene for SEWA) to 53.84 percent (chrysene for RUCA, although coronene has a similar CV for ANAK). The number of sites for which a given pollutant has a CV greater than 15 percent varies from none (14 pollutants) to two (four pollutants).

The pollutant-specific average CV, as shown in orange in Table 31-5, ranges from 1.04 percent (dibenz(a,h)anthracene) to 21.28 percent (chrysene). The precision for dibenz(a,h)anthracene is based on a single pair of measurements greater than the MDL. The site-specific average CV, as shown in green in Table 31-5, ranges from 5.93 percent (SEWA) to 17.21 percent (ANAK). ANAK is the only site with a site-specific average CV greater than 15 percent. The overall average method precision was 10.28 percent.

**Table 31-5. PAH Method Precision: Coefficient of Variation
Based on Collocated Samples by Site and Pollutant**

Pollutant	ANAK	DEMI	RUCA	SEWA	SYFL	# of Pairs	Average by Pollutant
Acenaphthene	8.90	8.70	9.31	5.62	4.18	28	7.34
Acenaphthylene	10.17	9.15	16.90	7.71	3.16	19	9.42
Anthracene	9.06	7.03	8.65	5.25	1.96	20	6.39
Benzo(a)anthracene	9.35	12.77	1.18	0.78	--	11	6.02
Benzo(a)pyrene	9.23	11.64	0.97	4.88	--	10	6.68
Benzo(b)fluoranthene	14.70	10.44	9.71	1.06	7.43	20	8.67
Benzo(e)pyrene	13.52	9.68	2.78	3.49	--	14	7.37
Benzo(g,h,i)perylene	29.75	6.29	6.95	5.89	4.96	17	10.77
Benzo(k)fluoranthene	12.75	10.53	4.86	13.23	--	9	10.34
Chrysene	32.27	6.34	53.84	4.22	9.72	28	21.28
Coronene	53.37	3.08	13.88	8.00	--	8	19.58
Cyclopenta[cd]pyrene	36.74	--	2.09	5.87	--	5	14.90
Dibenz(a,h)anthracene	1.04	--	--	--	--	1	1.04
Fluoranthene	18.62	6.69	33.10	6.20	7.86	28	14.50
Fluorene	7.84	6.58	10.50	7.88	4.36	27	7.43
9-Fluorenone	13.58	7.71	12.85	6.56	3.99	28	8.94
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	--	--
Naphthalene	7.23	6.17	10.26	4.53	8.89	28	7.42
Perylene	7.25	--	--	9.42	--	4	8.33
Phenanthrene	12.65	6.52	11.75	4.33	4.25	28	7.90
Pyrene	30.40	6.53	39.95	6.37	8.54	28	18.36
Retene	22.93	4.59	20.95	7.25	10.20	18	13.19
Average by Site	17.21	7.80	14.24	5.93	6.12	379	10.28
# of Pairs Collected per Site	6	7	6	6	3		

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

BOLD ITALICS = EPA-designated NATTS Site

31.2.5 Metals Method Precision

The method precision for all collocated metals samples are presented in Table 31-6 as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the metals listed. All samples evaluated in this section are collocated samples. The results from collocated samples exhibit low- to mid-level variability, ranging from a CV of 1.02 percent (antimony for ASKY-M) to 49.11 percent (cobalt for NBIL). The number of sites for which a given pollutant has a CV greater than 15 percent varies from none (chromium) to eight (mercury); with several metals exceeding 15 percent for only one site.

The pollutant-specific average CV, as shown in orange in Table 31-6, ranges from 6.12 percent (chromium) to 24.51 percent (mercury), with five of the 11 metals with an average CV greater than 15 percent. The site-specific average CV, as shown in green in Table 31-6, ranges from 7.93 percent (ASKY-M) to 20.71 percent (GLKY). GLKY and NBIL have site-specific average CVs greater than 15 percent. The overall average method precision for metals is 13.37 percent.

**Table 31-6. Metals Method Precision: Coefficient of Variation
Based on Collocated Samples by Site and Pollutant**

Pollutant	ASKY-M	BOMA	BTUT	GLKY	NBIL
Antimony	1.02	6.84	2.95	20.71	21.81
Arsenic	6.79	21.37	10.13	13.40	6.34
Beryllium	7.03	20.00	20.00	--	28.28
Cadmium	2.39	19.98	28.53	35.74	4.94
Chromium	--	--	--	--	5.27
Cobalt	24.11	7.76	7.55	12.18	49.11
Lead	2.44	3.87	2.77	18.50	12.30
Manganese	1.51	3.54	6.26	17.66	7.15
Mercury	22.34	16.33	15.71	31.34	38.88
Nickel	4.15	30.19	9.20	26.99	--
Selenium	7.55	13.90	35.69	9.85	9.63
Average by Site	7.93	14.38	13.88	20.71	18.37
# of Pairs Collected per Site	5	28	5	29	9

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-6. Metals Method Precision: Coefficient of Variation
Based on Collocated Samples by Site and Pollutant (Continued)**

Pollutant	<i>S4MO</i>	TOOK	<i>UNVT</i>	# of Pairs	Average by Pollutant
Antimony	3.77	12.23	38.79	190	13.52
Arsenic	13.99	4.76	5.49	169	10.28
Beryllium	17.32	8.33	--	72	16.83
Cadmium	8.25	19.73	17.00	191	17.07
Chromium	--	6.96	--	30	6.12
Cobalt	15.34	9.60	12.65	175	17.29
Lead	2.92	6.54	1.62	191	6.37
Manganese	5.19	5.82	4.91	191	6.50
Mercury	27.63	15.58	28.28	103	24.51
Nickel	21.97	7.74	15.71	136	16.57
Selenium	7.55	3.96	8.32	137	12.06
Average by Site	12.39	9.20	14.75	1,585	13.37
# of Pairs Collected per Site	55	54	6		

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

BOLD ITALICS = EPA-designated NATTS Site

31.2.6 Hexavalent Chromium Method Precision

Table 31-7 presents the method precision results from collocated hexavalent chromium samples as the CV per site and the overall average CV for the method. All samples evaluated in this section are collocated samples. The results from collocated samples exhibit low- to high-level variability. The site-specific CV ranges from 0.11 percent (SEWA) to 82.40 percent (SKFL); the CVs for seven of the 14 sites collecting collocated hexavalent chromium samples are greater than 15 percent. The overall average method precision of hexavalent chromium is 20.51 percent, as shown in orange in Table 31-7. This is the only method exceeding the MQO of 15 percent CV for method precision. Note, however, that most sites sampling hexavalent chromium discontinued sampling this pollutant at the end of July 2013 and the precision calculations are based on relatively few pairs; precision for 10 of the 14 sites is based on two or fewer samples.

Table 31-7. Hexavalent Chromium Method Precision: Coefficient of Variation Based on Collocated Samples by Site

Site	CV (%)	# of Pairs
<i>BOMA</i>	8.26	2
<i>BTUT</i>	15.50	1
<i>BXNY</i>	11.61	3
<i>CAMS 35</i>	27.55	3
<i>DEMI</i>	7.52	2
<i>GPCO</i>	5.37	1
<i>NBIL</i>	2.10	1
<i>PRRI</i>	32.79	1
<i>PXSS</i>	33.34	3
<i>RIVA</i>	35.53	2
<i>S4MO</i>	17.19	4
<i>SDGA</i>	7.92	1
<i>SEWA</i>	0.11	1
<i>SKFL</i>	82.40	2
Average CV	20.51	
# of Pairs	27	

Bold = CV greater than 15 percent

Orange shading indicates the average CV for this method.

BOLD ITALICS = EPA-designated NATTS Site

31.3 Analytical Precision

Analytical precision is a measurement of random errors associated with the process of analyzing environmental samples. These errors may result from various factors, including random “noise” inherent to analytical instruments. Laboratories can evaluate the analytical precision of ambient air samples by comparing concentrations measured during multiple analyses of a single sample (i.e., replicate samples). Replicate analyses were run on duplicate or collocated samples collected during the program year. CVs were calculated for every replicate analysis run on duplicate or collocated samples collected during the program year. In addition, replicate analyses were also run on select individual samples to provide an indication of analytical precision for monitoring sites unable to collect duplicate or collocated samples (i.e., samplers “unequipped” to collect duplicate or collocated samples). Individual samples with replicate analyses were also factored into the CV calculations for analytical precision. However, only results at or above the MDL were used in these calculations, similar to the calculation of method precision discussed in Section 31.2.

Table 31-8 presents the 2013 NMP analytical precision for VOCs, SNMOCs, carbonyl compounds, PAHs, metals, and hexavalent chromium, presented as average CV (expressed as a percentage). The average CV for each method met the program MQO of 15 percent for precision. The analytical precision for all methods is less than 9 percent. This table also includes the number of pairs that were included in the calculation of the analytical precision. The number of pairs including those with concentrations less than the MDL is also included in Table 31-8 to provide an indication of the effect that excluding those with concentrations less than the MDL has on the population of pairs in the dataset.

Table 31-8. Analytical Precision by Analytical Method

Method/Pollutant Group	Average Coefficient of Variation (%)	Number of Pairs Included in the Calculation	Total Number of Pairs Without the > MDL exclusion
VOCs (TO-15)	5.81	9,197	11,608
SNMOCs	4.20	1,742	2,089
Carbonyl Compounds (TO-11A)	2.52	3,626	3,631
PAHs (TO-13)	3.91	2,073	2,520
PAHs/Phenols	3.16	118	149
Metals Analysis (Method IO-3.5/FEM)	5.98	3,744	4,815
Hexavalent Chromium (ASTM D7641)	8.53	58	58
MQO	15.00 percent CV		

Tables 31-9 through 31-15 present analytical precision for VOCs, SNMOCs, carbonyl compounds, PAHs, PAH/Phenols, metals, and hexavalent chromium, respectively, as the CV per pollutant per site and the average CV per pollutant, per site, and per method. Pollutants exceeding the 15 percent MQO for CV are bolded in each table. In Tables 31-9 through 31-15, the number of pairs in comparison to the respective tables listed for duplicate or collocated analyses in Tables 31-2 through 31-7 is higher, the reason for which is two-fold. One reason is because each primary and duplicate (or collocated) sample produces a replicate analysis. The second reason is due to replicates run on individual samples. This is also the reason the number of sites provided in Tables 31-9 through 31-15 is higher than Tables 31-2 through 31-7. Note that collocated samples were not collected at KMMS, the one NMP site at which PAHs/Phenols were

collected, thus, this site/method has no corresponding table in Section 31.2 for method precision. The replicate analyses of duplicate, collocated, and individual samples indicate that the analytical precision level is within the program MQOs.

31.3.1 VOC Analytical Precision

Table 31-9 presents analytical precision results from replicate analyses of duplicate, collocated, and select individual VOC samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the VOCs listed. The analytical precision results from replicate analyses show that, for most of the pollutants, the VOC analytical precision is within 15 percent. The CV ranged from 0 percent (several pollutants and several sites) to 62.11 percent (methyl *tert*-butyl ether for GPCO). The number of sites for which a given pollutant has a CV greater than 15 percent varies from none (44 pollutants) to six (methyl *tert*-butyl ether).

The pollutant-specific average CV, as shown in orange in Table 31-9, ranges from 0 percent (1,1,2,2-tetrachloroethane) to 21.55 percent (methyl *tert*-butyl ether). The CV for 1,1,2,2-tetrachloroethane is based on a single pair of samples collected at ELNJ, the only site for which a pair of measurements greater than the MDL were collected. The site-specific average CV, as shown in green in Table 31-9, ranges from 4.04 percent (CCKY) to 8.85 percent (UNVT). The overall average analytical precision is 5.81 percent. Note that the results for acrolein, acetonitrile, acrylonitrile, and carbon disulfide were excluded from the precision calculations due to the issues described in Section 3.2.

Sites at which duplicate samples were collected are highlighted in blue in Table 31-9, sites at which collocated samples were collected are highlighted in purple, and sites at which replicates were run on individual samples are highlighted in brown. Collocated VOC samples were collected at only three of the sites shown in Table 31-9 (BURVT, PXSS, and TVKY); replicates were run on individual VOC samples for nine sites, and the remainder of sites collected duplicate VOC samples. The average CV for sites that collected duplicate samples was calculated and is shown in Table 31-9 in blue, the average CV for sites collecting collocated samples is shown in purple, and the average CV for sites where replicates were run on individual samples is shown in brown. The average CV for all three precision types meets the MQO of

15 percent, with the variability ranging from 5.18 percent (replicates run on individual samples) to 6.11 percent (replicates run on duplicate samples).

**Table 31-9. VOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant**

Pollutant	ADOK	ANAK	ASKY	ATKY	BLKY	BTUT	BURVT	CCKY
Acetylene	4.92	4.88	5.10	2.28	4.16	7.58	6.57	2.29
<i>tert</i> -Amyl Methyl Ether	--	--	--	--	--	--	--	--
Benzene	7.26	4.10	6.37	4.60	6.83	4.59	5.62	3.41
Bromochloromethane	--	--	--	--	--	--	--	--
Bromodichloromethane	--	--	--	--	--	--	--	--
Bromoform	--	--	--	--	--	--	--	--
Bromomethane	--	10.50	14.63	7.66	10.50	6.68	9.22	4.71
1,3-Butadiene	4.18	7.96	7.81	15.99	16.29	2.10	10.68	1.39
Carbon Tetrachloride	5.91	4.13	4.95	3.29	2.10	4.66	4.26	3.93
Chlorobenzene	--	--	--	--	--	--	--	--
Chloroethane	--	--	--	--	--	--	12.26	--
Chloroform	2.67	7.44	9.85	5.41	7.60	5.88	8.25	2.74
Chloromethane	6.26	2.08	3.43	1.87	2.53	3.35	4.10	0.86
Chloroprene	--	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--	--	--
1,2-Dibromoethane	--	--	--	--	--	--	--	--
<i>m</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>o</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>p</i> -Dichlorobenzene	--	9.39	--	--	--	--	--	--
Dichlorodifluoromethane	5.38	2.47	4.30	1.72	2.53	3.64	3.99	0.79
1,1-Dichloroethane	--	--	--	--	--	--	--	--
1,2-Dichloroethane	9.97	6.26	8.57	3.74	7.73	4.80	7.34	3.59
1,1-Dichloroethene	--	--	--	--	--	2.48	--	--
<i>cis</i> -1,2-Dichloroethylene	--	--	--	--	--	--	--	--
<i>trans</i> -1,2-Dichloroethylene	--	--	--	--	--	--	10.80	--
Dichloromethane	4.63	3.35	6.19	6.57	2.22	2.10	4.70	1.49
1,2-Dichloropropane	--	--	--	--	--	--	--	--
<i>cis</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-9. VOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant**

Pollutant	ADOK	ANAK	ASKY	ATKY	BLKY	BTUT	BURVT	CKKY
<i>trans</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--
Dichlorotetrafluoroethane	8.74	7.56	5.94	4.86	5.79	5.63	8.09	2.57
Ethyl Acrylate	--	--	--	--	--	--	--	--
Ethyl <i>tert</i> -Butyl Ether	--	--	--	--	--	5.79	--	--
Ethylbenzene	9.26	5.42	9.20	17.81	4.16	3.79	7.63	6.88
Hexachloro-1,3-butadiene	--	--	--	--	--	--	--	--
Methyl Isobutyl Ketone	19.83	4.03	7.92	8.19	6.01	5.39	9.24	2.60
Methyl Methacrylate	--	--	--	5.66	--	--	--	10.10
Methyl <i>tert</i> -Butyl Ether	--	--	4.29	--	--	6.34	--	--
<i>n</i> -Octane	11.58	8.72	11.18	16.22	7.22	10.80	9.02	7.54
Propylene	3.50	2.04	4.14	3.77	3.84	3.59	4.33	1.00
Styrene	9.62	9.64	10.85	15.48	0.00	3.35	8.69	8.14
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	--
Tetrachloroethylene	--	7.80	7.14	--	--	2.86	6.86	4.88
Toluene	7.59	3.70	5.87	5.45	8.92	8.54	5.02	3.26
1,2,4-Trichlorobenzene	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--	--
1,1,2-Trichloroethane	--	--	--	--	--	--	--	--
Trichloroethylene	--	--	--	--	--	--	7.13	--
Trichlorofluoromethane	3.85	2.24	3.70	1.62	2.36	3.10	4.40	0.91
Trichlorotrifluoroethane	5.13	2.30	4.92	2.85	2.20	3.32	4.46	2.69
1,2,4-Trimethylbenzene	8.01	7.42	6.65	18.64	0.00	4.17	7.78	5.56
1,3,5-Trimethylbenzene	9.42	7.79	14.77	--	0.00	6.22	11.65	9.87
Vinyl chloride	--	--	--	2.10	4.04	--	--	2.44
<i>m,p</i> -Xylene	7.36	4.42	8.43	12.86	10.89	3.49	6.70	4.92
<i>o</i> -Xylene	7.19	5.11	9.65	14.95	0.00	4.68	6.79	6.45
Average by Site	7.37	5.63	7.43	7.65	4.91	4.77	7.24	4.04
# of Pairs Collected per Site	6	12	5	5	5	9	55	5

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-9. VOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	CHNJ	CSNJ	DEMI	ELNJ	GLKY	GPCO	KMMS	LAKY
Acetylene	5.68	5.94	5.25	4.92	5.24	3.95	5.44	5.34
<i>tert</i> -Amyl Methyl Ether	--	--	--	--	--	--	--	--
Benzene	5.67	6.33	4.14	4.43	3.85	6.03	5.61	5.09
Bromochloromethane	--	--	--	--	--	--	--	--
Bromodichloromethane	--	--	--	--	--	--	--	--
Bromoform	--	--	--	--	--	--	--	--
Bromomethane	10.46	19.72	--	21.48	5.19	7.51	9.40	8.11
1,3-Butadiene	24.32	6.06	6.51	4.83	6.80	13.30	12.32	7.07
Carbon Tetrachloride	4.55	6.56	5.22	4.86	4.86	4.41	4.93	5.66
Chlorobenzene	--	--	--	--	--	--	--	--
Chloroethane	4.66	2.55	--	4.56	--	--	--	0.00
Chloroform	6.21	5.46	5.73	5.23	7.00	4.59	6.67	6.33
Chloromethane	4.05	4.04	4.49	3.99	5.28	2.23	4.16	2.77
Chloroprene	--	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--	--	--
1,2-Dibromoethane	--	--	--	--	--	--	--	--
<i>m</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>o</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>p</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
Dichlorodifluoromethane	4.09	3.63	4.51	3.57	5.21	2.56	4.41	3.07
1,1-Dichloroethane	--	--	--	--	--	--	--	2.24
1,2-Dichloroethane	7.50	11.77	11.57	5.35	7.29	7.55	7.69	12.41
1,1-Dichloroethene	--	--	--	--	--	--	--	--
<i>cis</i> -1,2-Dichloroethylene	--	--	--	--	--	--	--	--
<i>trans</i> -1,2-Dichloroethylene	--	--	--	--	--	--	--	--
Dichloromethane	7.05	3.38	5.07	4.46	4.58	3.83	6.47	4.32
1,2-Dichloropropane	--	--	--	--	--	--	--	--
<i>cis</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-9. VOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	CHNJ	CSNJ	DEMI	ELNJ	GLKY	GPCO	KMMS	LAKY
<i>trans</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--
Dichlorotetrafluoroethane	6.29	7.44	7.40	6.22	4.83	8.44	6.03	7.26
Ethyl Acrylate	--	--	--	--	--	--	--	--
Ethyl <i>tert</i> -Butyl Ether	5.87	8.23	--	4.61	--	5.52	--	--
Ethylbenzene	15.86	4.71	5.85	4.70	6.92	6.26	8.35	10.60
Hexachloro-1,3-butadiene	--	--	--	--	--	--	--	--
Methyl Isobutyl Ketone	12.94	5.56	9.58	9.36	5.47	4.56	7.14	9.47
Methyl Methacrylate	--	3.27	--	6.50	--	2.64	--	--
Methyl <i>tert</i> -Butyl Ether	14.25	15.78	--	26.92	10.88	62.11	--	--
<i>n</i> -Octane	7.44	5.69	7.91	3.95	6.27	9.22	13.89	7.36
Propylene	5.37	3.79	4.04	3.69	5.84	2.69	4.16	1.97
Styrene	7.05	4.88	5.36	7.85	10.15	5.12	17.00	6.51
1,1,2,2-Tetrachloroethane	--	--	--	0.00	--	--	--	--
Tetrachloroethylene	10.25	3.71	6.27	5.07	--	6.47	8.31	--
Toluene	8.67	5.88	4.66	3.73	3.79	4.01	5.87	4.74
1,2,4-Trichlorobenzene	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	6.61	--	--	--	--
1,1,2-Trichloroethane	--	--	--	--	--	--	--	0.00
Trichloroethylene	--	2.96	--	5.88	--	--	2.70	--
Trichlorofluoromethane	3.55	3.63	4.18	3.68	3.34	2.61	3.85	3.20
Trichlorotrifluoroethane	3.50	4.19	4.05	4.05	4.73	3.03	4.09	5.33
1,2,4-Trimethylbenzene	8.62	7.22	6.19	4.35	9.10	6.88	8.33	3.47
1,3,5-Trimethylbenzene	7.35	7.31	7.30	6.45	9.68	6.32	16.70	2.13
Vinyl chloride	--	--	--	--	--	--	12.31	3.98
<i>m,p</i> -Xylene	12.57	5.03	4.78	3.89	6.20	5.49	6.70	6.42
<i>o</i> -Xylene	15.64	5.78	4.90	3.63	7.44	6.49	6.87	4.85
Average by Site	8.50	6.22	5.87	6.09	6.25	7.55	7.67	5.17
# of Pairs Collected per Site	12	10	12	12	12	14	12	5

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

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**Table 31-9. VOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	LEKY	NBIL	NBNJ	OCOK	PXSS	ROIL	RUVT	S4MO
Acetylene	2.95	6.08	6.23	6.85	2.06	5.18	6.80	6.24
<i>tert</i> -Amyl Methyl Ether	--	--	--	--	--	--	--	--
Benzene	1.44	7.22	6.66	3.70	4.27	5.26	8.52	3.59
Bromochloromethane	--	--	--	--	--	--	--	--
Bromodichloromethane	--	6.54	--	--	--	--	--	--
Bromoform	--	2.06	--	--	--	--	--	--
Bromomethane	4.00	3.02	6.37	1.74	8.74	4.35	2.86	4.94
1,3-Butadiene	6.57	7.43	4.95	14.93	3.59	10.82	6.88	6.00
Carbon Tetrachloride	1.89	6.44	4.94	5.29	4.76	3.89	8.45	3.97
Chlorobenzene	1.40	--	--	--	--	--	--	--
Chloroethane	--	5.78	6.96	1.27	3.02	3.63	--	7.86
Chloroform	4.94	4.83	6.34	6.33	3.75	3.30	6.03	5.61
Chloromethane	2.83	3.64	3.19	3.97	2.59	2.04	6.28	3.80
Chloroprene	--	--	--	--	--	--	--	--
Dibromochloromethane	--	4.35	--	--	--	--	--	--
1,2-Dibromoethane	--	--	--	--	--	--	--	--
<i>m</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>o</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>p</i> -Dichlorobenzene	16.32	--	--	--	2.91	--	--	5.41
Dichlorodifluoromethane	2.37	3.37	3.28	3.78	2.22	3.95	7.00	3.96
1,1-Dichloroethane	--	--	--	--	--	--	--	--
1,2-Dichloroethane	8.20	4.60	6.09	8.58	6.89	6.23	3.30	7.50
1,1-Dichloroethene	--	--	--	--	--	--	--	--
<i>cis</i> -1,2-Dichloroethylene	--	--	--	--	--	--	--	--
<i>trans</i> -1,2-Dichloroethylene	--	--	--	--	0.00	--	2.57	--
Dichloromethane	2.68	4.48	2.83	5.20	4.87	8.80	8.05	4.16
1,2-Dichloropropane	--	--	--	--	--	--	--	--
<i>cis</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

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**Table 31-9. VOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	LEKY	NBIL	NBNJ	OCOK	PXSS	ROIL	RUVT	S4MO
<i>trans</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--
Dichlorotetrafluoroethane	5.72	5.37	5.50	6.51	5.05	5.22	3.59	5.40
Ethyl Acrylate	--	--	--	--	--	--	--	--
Ethyl <i>tert</i> -Butyl Ether	--	7.51	4.60	--	--	--	--	--
Ethylbenzene	4.49	3.66	11.88	8.83	3.54	6.56	3.54	6.21
Hexachloro-1,3-butadiene	--	--	--	--	--	--	--	--
Methyl Isobutyl Ketone	2.10	7.83	9.19	8.96	5.51	10.43	7.41	9.62
Methyl Methacrylate	--	5.54	--	--	9.23	--	--	--
Methyl <i>tert</i> -Butyl Ether	--	--	31.44	0.00	--	--	--	--
<i>n</i> -Octane	4.70	5.38	11.43	9.69	3.11	8.15	3.18	5.19
Propylene	0.85	4.02	3.92	5.47	2.73	4.83	6.86	3.48
Styrene	7.76	7.34	4.38	8.96	3.39	4.47	4.86	6.74
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	--
Tetrachloroethylene	8.67	5.62	5.72	3.03	5.42	3.93	3.03	4.49
Toluene	3.21	6.24	4.50	4.88	2.93	6.39	4.04	4.04
1,2,4-Trichlorobenzene	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--	--
1,1,2-Trichloroethane	--	--	--	--	--	--	--	--
Trichloroethylene	--	--	6.62	--	--	--	--	8.67
Trichlorofluoromethane	1.72	2.99	3.12	3.79	2.00	2.57	6.53	3.55
Trichlorotrifluoroethane	1.77	3.74	3.51	4.27	3.33	3.38	7.28	3.43
1,2,4-Trimethylbenzene	4.70	4.98	6.63	8.79	4.53	7.11	4.08	6.00
1,3,5-Trimethylbenzene	7.57	5.00	3.48	9.88	6.14	17.27	3.23	3.03
Vinyl chloride	--	2.86	--	--	--	--	--	0.00
<i>m,p</i> -Xylene	3.64	4.91	8.08	6.93	2.90	5.72	3.40	5.48
<i>o</i> -Xylene	4.70	4.00	7.92	7.40	3.93	6.36	2.98	5.89
Average by Site	4.51	5.06	6.78	6.12	4.05	5.99	5.23	5.15
# of Pairs Collected per Site	4	14	12	12	14	10	5	12

-- = No pairs with concentrations greater than or equal to the MDL.

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Green shading indicates the site-specific average CV for this method.

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Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

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**Table 31-9. VOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	SEWA	SPAZ	SPIL	SSMS	TMOK	TOOK	TROK	TVKY
Acetylene	3.59	5.17	6.04	3.97	7.66	5.12	3.86	5.64
<i>tert</i> -Amyl Methyl Ether	--	--	--	--	--	--	--	--
Benzene	2.76	3.40	4.64	5.14	7.42	6.38	5.26	5.53
Bromochloromethane	--	--	--	--	--	--	--	--
Bromodichloromethane	--	--	--	--	--	--	--	--
Bromoform	--	--	--	--	--	--	--	--
Bromomethane	4.04	6.15	16.67	5.81	5.59	7.86	6.05	7.86
1,3-Butadiene	5.06	7.02	6.43	6.04	5.88	4.58	12.08	6.38
Carbon Tetrachloride	2.94	3.66	4.91	5.57	7.19	14.91	4.73	4.54
Chlorobenzene	--	--	--	--	--	--	--	--
Chloroethane	--	--	--	5.06	--	4.69	--	9.32
Chloroform	4.77	2.56	7.27	5.67	14.31	7.20	7.90	5.55
Chloromethane	3.02	6.05	5.15	3.08	5.72	3.35	3.83	3.89
Chloroprene	--	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--	--	--
1,2-Dibromoethane	--	--	--	--	--	--	--	--
<i>m</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>o</i> -Dichlorobenzene	--	--	--	--	--	--	--	--
<i>p</i> -Dichlorobenzene	--	4.08	--	--	6.42	--	--	3.50
Dichlorodifluoromethane	2.89	4.73	4.56	3.16	5.69	3.23	3.81	3.45
1,1-Dichloroethane	--	--	--	--	--	--	--	7.17
1,2-Dichloroethane	7.28	3.68	9.39	6.75	8.84	6.01	5.26	6.52
1,1-Dichloroethene	--	--	--	--	--	--	--	6.53
<i>cis</i> -1,2-Dichloroethylene	--	--	--	--	--	--	--	--
<i>trans</i> -1,2-Dichloroethylene	--	--	--	--	--	--	10.35	4.24
Dichloromethane	3.27	2.34	5.48	6.07	6.87	4.86	3.59	4.47
1,2-Dichloropropane	--	--	--	--	--	--	--	--
<i>cis</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

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**Table 31-9. VOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	SEWA	SPAZ	SPIL	SSMS	TMOK	TOOK	TROK	TVKY
<i>trans</i> -1,3-Dichloropropene	--	--	--	--	--	--	--	--
Dichlorotetrafluoroethane	4.80	4.55	5.50	4.71	7.21	6.14	6.82	7.56
Ethyl Acrylate	--	--	--	--	--	--	--	--
Ethyl <i>tert</i> -Butyl Ether	--	--	10.09	--	--	--	--	--
Ethylbenzene	6.82	4.62	6.94	3.68	4.09	4.60	3.65	10.69
Hexachloro-1,3-butadiene	--	--	--	--	--	--	--	--
Methyl Isobutyl Ketone	7.75	8.46	7.40	6.07	7.88	7.58	6.83	6.56
Methyl Methacrylate	--	0.00	--	--	--	5.02	--	3.29
Methyl <i>tert</i> -Butyl Ether	--	--	50.87	53.64	0.00	3.63	--	--
<i>n</i> -Octane	14.15	6.64	9.51	6.24	6.18	6.83	3.28	10.59
Propylene	2.52	3.54	4.01	2.88	7.44	4.77	4.39	7.53
Styrene	3.33	9.62	9.31	4.73	5.15	5.26	12.47	8.30
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	--
Tetrachloroethylene	3.01	6.02	5.96	2.70	10.32	6.36	4.75	8.31
Toluene	2.29	2.31	5.03	2.95	5.11	5.68	2.77	6.31
1,2,4-Trichlorobenzene	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--	8.84
1,1,2-Trichloroethane	--	--	--	--	--	--	--	6.62
Trichloroethylene	--	--	8.63	4.55	--	--	--	0.00
Trichlorofluoromethane	2.97	2.25	3.52	3.00	5.34	3.40	3.61	3.35
Trichlorotrifluoroethane	3.85	2.30	3.40	3.48	4.91	3.19	4.12	4.65
1,2,4-Trimethylbenzene	7.06	5.06	8.67	5.19	4.79	4.74	4.50	11.24
1,3,5-Trimethylbenzene	3.49	10.20	5.69	6.42	3.91	5.59	5.38	8.09
Vinyl chloride	--	--	--	4.56	--	--	--	4.19
<i>m,p</i> -Xylene	4.92	3.40	7.25	3.73	4.19	4.05	3.45	10.54
<i>o</i> -Xylene	5.99	4.79	8.11	4.90	4.42	4.47	3.62	11.12
Average by Site	4.69	4.72	8.53	6.42	6.25	5.54	5.45	6.54
# of Pairs Collected per Site	12	8	12	12	12	14	14	62

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-9. VOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	UNVT	YUOK	# of Pairs	Average by Pollutant	Average for Duplicate Pairs	Average for Collocated Pairs	Average for Unequipped
Acetylene	9.44	5.47	437	5.23	5.46	4.76	4.84
<i>tert</i> -Amyl Methyl Ether	--	--	--	--	--	--	--
Benzene	8.66	4.50	438	5.24	5.21	5.14	5.37
Bromochloromethane	--	--	--	--	--	--	--
Bromodichloromethane	--	--	10	6.54	6.54	--	--
Bromoform	--	--	3	2.06	2.06	--	--
Bromomethane	7.49	9.60	181	8.09	8.35	8.61	7.34
1,3-Butadiene		9.81	356	8.24	8.29	6.88	8.63
Carbon Tetrachloride	6.35	4.65	437	5.10	5.43	4.52	4.48
Chlorobenzene	--	--	1	1.40	--	--	1.40
Chloroethane	--	--	41	5.12	4.70	8.20	0.00
Chloroform	8.26	8.91	310	6.19	6.33	5.85	5.97
Chloromethane	8.50	1.78	438	3.77	3.75	3.53	3.90
Chloroprene	--	--	--	--	--	--	--
Dibromochloromethane	--	--	7	4.35	4.35	--	--
1,2-Dibromoethane	--	--	--	--	--	--	--
<i>m</i> -Dichlorobenzene	--	--	--	--	--	--	--
<i>o</i> -Dichlorobenzene	--	--	--	--	--	--	--
<i>p</i> -Dichlorobenzene	--	--	27	6.86	7.07	3.20	10.20
Dichlorodifluoromethane	8.61	1.83	438	3.76	3.77	3.22	3.90
1,1-Dichloroethane	--	--	11	4.71	--	7.17	2.24
1,2-Dichloroethane	7.49	7.79	329	7.16	7.46	6.92	6.52
1,1-Dichloroethene	--	--	6	4.50	2.48	6.53	--
<i>cis</i> -1,2-Dichloroethylene	--	--	--	--	--	--	--
<i>trans</i> -1,2-Dichloroethylene	--	11.47	15	6.57	10.91	5.01	2.57
Dichloromethane	6.82	3.26	423	4.66	4.72	4.68	4.52
1,2-Dichloropropane	--	--	--	--	--	--	--
<i>cis</i> -1,3-Dichloropropene	--	--	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-9. VOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	UNVT	YUOK	# of Pairs	Average by Pollutant	Average for Duplicate Pairs	Average for Collocated Pairs	Average for Unequipped
<i>trans</i> -1,3-Dichloropropene	--	--	--	--	--	--	--
Dichlorotetrafluoroethane	9.74	5.00	437	6.10	6.22	6.90	5.56
Ethyl Acrylate	--	--	--	--	--	--	--
Ethyl <i>tert</i> -Butyl Ether	--	--	55	6.53	6.53	--	--
Ethylbenzene	10.50	5.94	402	6.99	6.54	7.28	7.98
Hexachloro-1,3-butadiene	--	--	--	--	--	--	--
Methyl Isobutyl Ketone	9.75	9.79	311	7.84	8.33	7.10	6.88
Methyl Methacrylate	--	--	24	5.12	4.59	6.26	5.25
Methyl <i>tert</i> -Butyl Ether	--	--	51	21.55	22.99	--	4.29
<i>n</i> -Octane	8.41	4.72	397	7.98	8.01	7.57	8.05
Propylene	9.39	1.87	438	4.07	4.01	4.86	3.93
Styrene	8.31	10.88	236	7.50	7.41	6.79	7.95
1,1,2,2-Tetrachloroethane	--	--	1	0.00	0.00	--	--
Tetrachloroethylene	--	8.66	171	5.91	5.76	6.86	5.95
Toluene	18.50	2.76	437	5.28	4.96	4.75	6.26
1,2,4-Trichlorobenzene	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	3	7.72	6.61	8.84	--
1,1,2-Trichloroethane	--	--	5	3.31	--	6.62	0.00
Trichloroethylene	--	--	24	5.24	5.71	3.57	--
Trichlorofluoromethane	8.03	2.04	438	3.35	3.36	3.25	3.37
Trichlorotrifluoroethane	7.82	3.34	438	3.90	3.77	4.15	4.13
1,2,4-Trimethylbenzene	6.18	4.74	364	6.51	6.52	7.85	6.04
1,3,5-Trimethylbenzene	--	7.75	198	7.35	7.34	8.62	6.82
Vinyl chloride	--	--	49	4.05	4.93	4.19	3.14
<i>m,p</i> -Xylene	7.32	4.36	413	6.01	5.59	6.71	6.81
<i>o</i> -Xylene	10.32	5.00	397	6.36	6.17	7.28	6.52
Average by Site	8.85	5.84	9,197	5.81	6.11	5.99	5.18
# of Pairs Collected per Site	11	7					

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

31.3.2 SNMOC Analytical Precision

Table 31-10 presents analytical precision results from replicate analyses of duplicate, collocated, and select individual samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the SNMOCs listed. The CV ranges from 0 percent (2,4-dimethylpentane for BMCO and 1-hexene for PACO) to 34.79 percent (1-nonene for NBIL). CVs for only seven pollutant-site combinations are greater than 15 percent.

The pollutant-specific average CV, as shown in orange in Table 31-10, ranges from 0 percent (1-hexene) to 16.42 percent (1-nonene). 1-Nonene is the only SNMOC with an average CV greater than 15 percent. The site-specific average CV, as shown in green in Table 31-10, ranges from 2.95 percent (PACO) to 5.20 percent (NBIL). The overall average analytical precision is 4.20 percent. Note that the results for TNMOC were not included in the precision calculations.

Sites at which duplicate samples were collected are highlighted in blue in Table 31-10 while sites at which replicates were run on individual samples are highlighted in brown. Collocated SNMOC samples were not collected at the NMP sites sampling SNMOC. Duplicate SNMOC samples were collected at only BTUT and NBIL; replicates were run on individual SNMOC samples collected at the five Garfield County, Colorado sites. The average CV for sites that collected duplicate samples was calculated and is shown in Table 31-10 in blue while the average CV for sites where replicates were run on individual samples is shown in brown. The variability ranges from 3.62 percent (replicates run on individual samples) to 5.24 percent (replicates run on duplicate samples).

**Table 31-10. SNMOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant**

Pollutant	BMCO	BRCO	BTUT	NBIL	PACO
Acetylene	2.84	6.13	4.78	7.88	4.66
Benzene	0.75	3.28	4.48	5.77	4.26
1,3-Butadiene	--	--	10.77	--	0.25
<i>n</i> -Butane	0.98	1.27	1.52	0.84	0.94
1-Butene	--	--	--	--	--
<i>cis</i> -2-Butene	--	--	3.70	--	2.99
<i>trans</i> -2-Butene	--	--	4.78	--	3.08
Cyclohexane	2.45	0.37	4.02	4.50	0.41
Cyclopentane	3.05	1.70	1.88	17.97	1.58
Cyclopentene	--	--	--	--	--
<i>n</i> -Decane	3.00	5.97	4.63	4.55	3.53
1-Decene	--	--	--	--	--
<i>m</i> -Diethylbenzene	--	--	--	--	--
<i>p</i> -Diethylbenzene	--	--	--	--	--
2,2-Dimethylbutane	3.81	4.07	7.19	10.81	3.45
2,3-Dimethylbutane	2.06	1.07	2.41	3.51	1.85
2,3-Dimethylpentane	7.55	4.39	2.30	4.45	2.76
2,4-Dimethylpentane	0.00	5.48	3.79	1.97	8.55
<i>n</i> -Dodecane	--	--	2.74	12.46	3.10
1-Dodecene	--	--	--	--	--
Ethane	0.34	0.58	2.25	0.57	0.50
2-Ethyl-1-butene	--	--	--	--	--
Ethylbenzene	3.82	4.90	6.11	7.01	6.80
Ethylene	3.23	2.61	2.22	1.16	0.74
<i>m</i> -Ethyltoluene	3.54	5.44	3.29	3.18	1.90
<i>o</i> -Ethyltoluene	2.98	--	10.50	5.01	4.06
<i>p</i> -Ethyltoluene	11.22	6.76	7.69	4.28	3.83
<i>n</i> -Heptane	0.93	3.47	5.30	4.69	2.98
1-Heptene	--	--	--	--	--
<i>n</i> -Hexane	2.57	1.22	2.68	1.74	1.42
1-Hexene	--	--	--	--	0.00

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

Table 31-10. SNMOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	BMCO	BRCO	BTUT	NBIL	PACO
<i>cis</i> -2-Hexene	--	--	--	--	--
<i>trans</i> -2-Hexene	--	--	--	--	--
Isobutane	1.01	0.87	2.70	1.28	0.29
Isobutene/1-Butene	--	--	--	--	--
Isobutylene	--	--	--	8.86	--
Isopentane	1.04	1.25	2.67	1.60	1.15
Isoprene	--	--	5.63	2.18	3.91
Isopropylbenzene	--	--	--	2.13	--
2-Methyl-1-butene	--	--	3.74	--	1.56
3-Methyl-1-butene	--	--	--	--	--
2-Methyl-1-pentene	--	--	--	--	--
4-Methyl-1-pentene	--	--	--	--	--
2-Methyl-2-butene	--	3.60	2.87	0.73	10.31
Methylcyclohexane	2.19	2.07	3.93	8.90	1.88
Methylcyclopentane	2.21	0.77	2.76	3.89	0.66
2-Methylheptane	2.32	5.62	5.34	--	2.49
3-Methylheptane	3.21	5.91	6.16	2.95	2.75
2-Methylhexane	2.32	2.29	2.82	5.70	2.12
3-Methylhexane	2.16	1.98	3.98	6.06	2.54
2-Methylpentane	2.98	1.33	2.40	2.89	1.14
3-Methylpentane	2.42	1.06	3.14	3.55	1.12
<i>n</i> -Nonane	3.54	8.42	6.48	2.36	3.29
1-Nonene	--	--	--	34.79	7.38
<i>n</i> -Octane	1.26	2.97	4.58	3.63	2.81
1-Octene	--	--	6.16	4.48	4.81
<i>n</i> -Pentane	1.49	1.49	1.09	1.83	1.40
1-Pentene	--	--	2.55	1.76	4.94
<i>cis</i> -2-Pentene	--	--	--	--	1.58
<i>trans</i> -2-Pentene	--	--	8.38	0.93	4.19
<i>a</i> -Pinene	3.85	3.55	14.92	4.39	--
<i>b</i> -Pinene	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

Table 31-10. SNMOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	BMCO	BRCO	BTUT	NBIL	PACO
Propane	0.34	0.77	1.20	0.47	0.68
<i>n</i> -Propylbenzene	3.28	--	7.26	4.98	0.65
Propylene	5.53	2.85	2.69	4.83	1.27
Propyne	--	--	--	--	--
Styrene	--	6.14	--	2.77	0.36
Toluene	0.86	3.80	1.91	4.32	3.79
<i>n</i> -Tridecane	--	--	10.11	19.68	--
1-Tridecene	--	--	--	--	--
1,2,3-Trimethylbenzene	16.97	--	10.24	3.11	3.94
1,2,4-Trimethylbenzene	8.73	5.20	3.46	5.26	2.66
1,3,5-Trimethylbenzene	9.50	7.02	6.26	3.95	3.58
2,2,3-Trimethylpentane	1.86	--	5.20	7.65	4.11
2,2,4-Trimethylpentane	--	--	3.49	3.62	--
2,3,4-Trimethylpentane	--	1.42	15.86	10.00	15.48
<i>n</i> -Undecane	0.94	2.53	5.86	4.71	4.23
1-Undecene	--	--	--	--	0.52
<i>m</i> -Xylene/ <i>p</i> -Xylene	3.37	4.83	1.92	3.69	3.60
<i>o</i> -Xylene	5.73	6.74	4.85	4.09	4.04
SNMOC (Sum of Knowns)	0.63	0.78	1.38	1.52	0.50
Sum of Unknowns	2.01	2.91	4.23	4.27	1.43
Average by Site	3.26	3.34	4.78	5.20	2.95
# of Pairs Collected per Site	4	4	9	14	4

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-10. SNMOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	RFCO	RICO	# of Pairs	Average by Pollutant	Average for Duplicate Pairs	Average for Unequipped
Acetylene	1.39	1.12	43	4.12	6.33	3.23
Benzene	4.83	3.11	37	3.78	5.13	3.25
1,3-Butadiene	9.75	13.86	7	8.66	10.77	7.96
<i>n</i> -Butane	1.86	1.66	43	1.29	1.18	1.34
1-Butene	--	--	--	--	--	--
<i>cis</i> -2-Butene	2.47	2.68	14	2.96	3.70	2.71
<i>trans</i> -2-Butene	3.57	1.46	17	3.22	4.78	2.70
Cyclohexane	3.94	2.17	41	2.55	4.26	1.87
Cyclopentane	5.22	1.75	30	4.73	9.92	2.66
Cyclopentene	--	--	--	--	--	--
<i>n</i> -Decane	12.16	6.38	33	5.75	4.59	6.21
1-Decene	--	--	--	--	--	--
<i>m</i> -Diethylbenzene	--	--	--	--	--	--
<i>p</i> -Diethylbenzene	--	--	--	--	--	--
2,2-Dimethylbutane	11.19	2.32	32	6.12	9.00	4.97
2,3-Dimethylbutane	5.22	1.99	39	2.59	2.96	2.44
2,3-Dimethylpentane	2.11	4.03	31	3.94	3.38	4.17
2,4-Dimethylpentane	--	6.03	13	4.30	2.88	5.01
<i>n</i> -Dodecane	--	--	9	6.10	7.60	3.10
1-Dodecene	--	--	--	--	--	--
Ethane	0.94	0.71	43	0.84	1.41	0.61
2-Ethyl-1-butene	--	--	--	--	--	--
Ethylbenzene	2.95	4.61	33	5.17	6.56	4.61
Ethylene	0.79	0.70	43	1.63	1.69	1.61
<i>m</i> -Ethyltoluene	1.54	5.02	34	3.41	3.23	3.49
<i>o</i> -Ethyltoluene	--	8.15	13	6.14	7.76	5.07
<i>p</i> -Ethyltoluene	10.21	5.71	23	7.10	5.98	7.55
<i>n</i> -Heptane	2.07	2.68	41	3.16	4.99	2.43
1-Heptene	--	--	--	--	--	--
<i>n</i> -Hexane	3.61	2.97	41	2.32	2.21	2.36
1-Hexene	--	--	1	0.00	--	0.00

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-10. SNMOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	RFCO	RICO	# of Pairs	Average by Pollutant	Average for Duplicate Pairs	Average for Unequipped
<i>cis</i> -2-Hexene	--	--	--	--	--	--
<i>trans</i> -2-Hexene	--	--	--	--	--	--
Isobutane	1.28	1.45	43	1.27	1.99	0.98
Isobutene/1-Butene	--	--	--	--	--	--
Isobutylene	3.94	--	3	6.40	8.86	3.94
Isopentane	1.31	0.79	22	1.40	2.13	1.11
Isoprene	5.45	4.18	19	4.27	3.90	4.51
Isopropylbenzene	--	--	3	2.13	2.13	--
2-Methyl-1-butene	3.53	2.31	9	2.79	3.74	2.47
3-Methyl-1-butene	--	--	--	--	--	--
2-Methyl-1-pentene	--	--	--	--	--	--
4-Methyl-1-pentene	--	--	--	--	--	--
2-Methyl-2-butene	2.48	3.67	11	3.94	1.80	5.02
Methylcyclohexane	2.98	2.45	38	3.49	6.42	2.32
Methylcyclopentane	2.61	2.29	41	2.17	3.33	1.71
2-Methylheptane	4.40	6.39	23	4.43	5.34	4.24
3-Methylheptane	3.02	4.86	23	4.12	4.56	3.95
2-Methylhexane	1.04	2.52	43	2.69	4.26	2.06
3-Methylhexane	--	2.41	27	3.19	5.02	2.27
2-Methylpentane	2.58	2.61	43	2.27	2.64	2.13
3-Methylpentane	3.20	1.90	41	2.34	3.35	1.94
<i>n</i> -Nonane	3.60	2.71	36	4.34	4.42	4.31
1-Nonene	7.09	--	6	16.42	34.79	7.23
<i>n</i> -Octane	2.52	3.14	38	2.99	4.10	2.54
1-Octene	3.59	--	21	4.76	5.32	4.20
<i>n</i> -Pentane	2.05	1.57	43	1.56	1.46	1.60
1-Pentene	3.45	7.97	17	4.13	2.15	5.45
<i>cis</i> -2-Pentene	--	--	1	1.58	--	1.58
<i>trans</i> -2-Pentene	--	5.21	10	4.68	4.65	4.70
<i>a</i> -Pinene	3.80	8.33	23	6.47	9.66	4.88
<i>b</i> -Pinene	--	--	--	--	--	--

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-10. SNMOC Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	RFCO	RICO	# of Pairs	Average by Pollutant	Average for Duplicate Pairs	Average for Unequipped
Propane	1.03	0.91	43	0.77	0.84	0.74
<i>n</i> -Propylbenzene	20.65	12.82	15	8.27	6.12	9.35
Propylene	2.11	1.32	43	2.94	3.76	2.62
Propyne	--	--	--	--	--	--
Styrene	4.83	1.06	7	3.03	2.77	3.09
Toluene	2.51	4.26	43	3.06	3.11	3.04
<i>n</i> -Tridecane	--	--	6	14.90	14.90	--
1-Tridecene	--	--	--	--	--	--
1,2,3-Trimethylbenzene	8.42	5.68	19	8.06	6.67	8.75
1,2,4-Trimethylbenzene	8.39	4.53	40	5.46	4.36	5.90
1,3,5-Trimethylbenzene	8.91	12.51	24	7.39	5.11	8.31
2,2,3-Trimethylpentane	--	--	11	4.71	6.43	2.99
2,2,4-Trimethylpentane	5.28	2.57	25	3.74	3.55	3.92
2,3,4-Trimethylpentane	9.19	2.69	29	9.11	12.93	7.19
<i>n</i> -Undecane	--	3.49	22	3.63	5.28	2.80
1-Undecene	--	--	1	0.52	--	0.52
<i>m</i> -Xylene/ <i>p</i> -Xylene	6.49	4.36	43	4.04	2.80	4.53
<i>o</i> -Xylene	11.35	6.12	40	6.13	4.47	6.80
SNMOC (Sum of Knowns)	1.06	0.84	43	0.96	1.45	0.76
Sum of Unknowns	1.97	1.98	43	2.69	4.25	2.06
Average by Site	4.56	3.84	1742	4.20	5.24	3.62
# of Pairs Collected per Site	4	4				

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

31.3.3 Carbonyl Compound Analytical Precision

Table 31-11 presents the analytical precision results from replicate analyses of duplicate, collocated, and select individual carbonyl compound samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV for the carbonyl compounds listed. The overall average variability was 2.52 percent, which is well within the program MQO of 15 percent CV. The analytical precision results from replicate analyses range from 0 percent (several pollutants at different sites) to 9.44 percent (hexaldehyde for PACO), indicating that every pollutant-site combination has a CV less than 15 percent.

The pollutant-specific average CV, as shown in orange in Table 31-11, ranges from 0.58 percent (acetone) to 4.16 percent (tolualdehydes). The site-specific average CV, as shown in green in Table 31-11, ranges from 0.18 percent (BMCO) to 3.83 percent (RICO). Note that the site-specific average CV for BMCO is based on a single replicate sample.

Sites at which duplicate samples were collected are highlighted in blue in Table 31-11, sites at which collocated samples were collected are highlighted in purple, and sites at which replicates were run on individual samples are highlighted in brown. Collocated carbonyl compound samples were collected at only three of the sites shown in Table 31-11 (DEMI, INDEM, and PXSS); replicates were run on individual samples for seven sites, and the remainder of sites collected duplicate samples. The average CV for sites that collected duplicate samples was calculated and is shown in Table 31-11 in blue, the average CV for sites collecting collocated samples is shown in purple, and the average CV for sites where replicates were run on individual samples is shown in brown. The average CV for all three precision types meets the MQO of 15 percent, with the variability ranging from 2.31 percent (replicates run on individual samples) to 2.79 percent (replicates run on collocated samples).

**Table 31-11. Carbonyl Compound Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant**

Pollutant	ADOK	ASKY	AZFL	BMCO	BRCO	BTUT	CHNJ	CSNJ
Acetaldehyde	0.76	0.58	1.93	0.61	0.81	0.31	0.85	0.62
Acetone	0.79	0.53	1.24	0.16	0.07	0.32	0.57	0.63
Benzaldehyde	4.39	0.00	4.61	0.00	2.43	3.84	3.00	2.91
2-Butanone	1.74	1.26	3.76	0.00	1.43	1.76	2.37	1.97
Butyraldehyde	2.56	1.27	4.59	0.00	3.72	0.63	2.94	0.92
Crotonaldehyde	1.76	1.21	3.80	0.00	7.16	1.67	3.54	2.43
2,5-Dimethylbenzaldehyde	--	--	--	--	--	--	--	--
Formaldehyde	1.76	0.66	1.80	0.99	1.86	0.46	1.41	1.02
Hexaldehyde	3.96	0.00	4.22	0.00	8.20	4.20	3.70	3.55
Isovaleraldehyde	--	--	--	--	--	--	--	--
Propionaldehyde	1.46	2.08	2.25	0.00	5.04	0.47	1.81	2.01
Tolualdehydes	3.03	4.88	4.39	0.00	5.03	3.23	5.98	4.10
Valeraldehyde	4.36	0.00	3.89	--	5.63	3.52	3.34	3.86
Average by Site	2.42	1.13	3.32	0.18	3.76	1.86	2.68	2.18
# of Pairs Collected per Site	6	1	12	1	5	8	12	12

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-11. Carbonyl Compound Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	<i>DEMI</i>	<i>ELNJ</i>	<i>GLKY</i>	<i>GPCO</i>	<i>INDEM</i>	<i>LEKY</i>	<i>NBIL</i>	<i>NBNJ</i>
Acetaldehyde	1.61	0.54	1.04	0.56	1.41	0.58	1.14	1.02
Acetone	0.45	0.37	1.11	0.22	1.03	0.22	0.62	0.74
Benzaldehyde	4.68	3.50	6.30	1.45	4.71	0.00	4.37	3.81
2-Butanone	2.05	2.52	2.54	0.62	2.09	0.47	2.64	1.58
Butyraldehyde	2.22	2.24	2.85	1.04	4.14	1.90	2.33	2.63
Crotonaldehyde	2.37	2.85	4.51	1.20	3.19	2.13	3.89	0.63
2,5-Dimethylbenzaldehyde	--	--	--	--	--	--	--	--
Formaldehyde	0.72	0.96	1.10	0.45	1.02	0.75	1.07	0.96
Hexaldehyde	3.57	3.68	4.47	2.80	4.72	4.35	3.13	5.46
Isovaleraldehyde	--	--	--	--	--	--	--	--
Propionaldehyde	1.73	1.31	2.54	0.80	3.83	0.00	2.39	1.71
Tolualdehydes	4.91	5.35	3.49	2.90	4.11	5.26	5.03	3.77
Valeraldehyde	4.19	2.95	7.33	3.46	4.34	4.88	5.28	6.80
Average by Site	2.59	2.39	3.39	1.41	3.15	1.87	2.90	2.65
# of Pairs Collected per Site	14	12	12	9	22	2	14	12

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-11. Carbonyl Compound Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	OCOK	ORFL	PACO	PXSS	RFCO	RICO	ROIL	S4MO
Acetaldehyde	0.64	0.68	0.71	1.99	4.29	0.88	0.88	0.62
Acetone	0.55	0.72	0.10	1.80	0.50	0.46	0.65	0.48
Benzaldehyde	3.99	3.50	3.65	2.65	0.00	6.63	1.89	3.88
2-Butanone	1.61	3.64	1.06	1.47	1.72	2.50	3.51	1.57
Butyraldehyde	2.00	3.66	5.20	2.16	--	4.61	3.40	1.55
Crotonaldehyde	2.11	1.38	3.38	2.75	--	3.06	2.90	1.62
2,5-Dimethylbenzaldehyde	--	--	--	--	--	--	--	--
Formaldehyde	1.02	1.27	1.93	1.69	0.00	2.43	0.69	1.69
Hexaldehyde	4.16	4.91	9.44	2.67	0.00	6.32	2.29	3.65
Isovaleraldehyde	--	--	--	--	--	--	--	--
Propionaldehyde	2.61	2.86	3.37	3.85	0.00	4.20	1.82	2.09
Tolualdehydes	4.24	5.27	6.00	3.85	--	3.07	4.05	4.33
Valeraldehyde	4.02	4.53	4.59	4.07	0.00	8.01	3.10	3.36
Average by Site	2.45	2.95	3.59	2.63	0.81	3.83	2.29	2.26
# of Pairs Collected per Site	12	14	5	13	1	5	12	12

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-11. Carbonyl Compound Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	SEWA	SKFL	SPIL	SYFL	TMOK	TOOK	TROK	WPIN
Acetaldehyde	1.90	0.79	0.89	1.80	0.60	0.99	0.60	1.13
Acetone	0.54	0.60	0.50	0.75	0.66	0.58	0.34	0.55
Benzaldehyde	4.18	4.45	3.59	4.33	2.66	5.39	4.26	4.23
2-Butanone	1.73	2.90	1.37	3.53	1.23	1.70	0.62	2.78
Butyraldehyde	2.85	3.78	1.90	3.49	1.78	2.30	2.81	3.89
Crotonaldehyde	3.85	2.37	1.49	1.72	2.17	2.36	1.67	3.32
2,5-Dimethylbenzaldehyde	--	--	--	--	--	--	--	--
Formaldehyde	2.15	1.63	0.45	1.11	0.80	0.81	0.68	0.79
Hexaldehyde	4.48	5.17	3.06	4.04	3.18	4.40	5.10	4.53
Isovaleraldehyde	--	--	--	--	--	--	--	--
Propionaldehyde	4.12	3.49	1.27	2.91	2.32	1.13	1.61	2.65
Tolualdehydes	3.37	4.96	4.07	3.84	3.13	4.74	4.49	3.63
Valeraldehyde	4.07	4.04	3.69	4.85	4.55	4.55	3.04	4.87
Average by Site	3.02	3.11	2.02	2.94	2.10	2.63	2.29	2.94
# of Pairs Collected per Site	12	12	10	12	12	12	14	18

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-11. Carbonyl Compound Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	YUOK	# of Pairs	Average by Pollutant	Average for Duplicate Pairs	Average for Collocated Pairs	Average for Unequipped
Acetaldehyde	0.71	338	1.04	0.91	1.67	1.21
Acetone	0.38	338	0.58	0.60	1.10	0.29
Benzaldehyde	4.23	336	3.44	3.86	4.01	1.82
2-Butanone	2.73	335	1.95	2.19	1.87	1.21
Butyraldehyde	3.34	337	2.65	2.59	2.84	2.79
Crotonaldehyde	1.01	337	2.48	2.36	2.77	2.82
2,5-Dimethylbenzaldehyde	--	--	--	--	--	--
Formaldehyde	0.88	338	1.12	1.09	1.14	1.23
Hexaldehyde	4.20	335	3.99	4.01	3.65	4.04
Isovaleraldehyde	--	--	--	--	--	--
Propionaldehyde	1.26	336	2.15	2.04	3.14	2.10
Tolualdehydes	4.64	274	4.16	4.18	4.29	4.04
Valeraldehyde	3.51	322	4.15	4.22	4.20	3.85
Average by Site	2.45	3,626	2.52	2.55	2.79	2.31
# of Pairs Collected per Site	8					

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting duplicate samples; purple shading identifies sites collecting collocated samples; brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

31.3.4 PAH Analytical Precision

Table 31-12 presents analytical precision results from replicate analyses of collocated and select individual samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the PAHs listed. The CV ranges from 0 percent (benzo(e)pyrene for CHSC and benzo(a)anthracene for WADC) to 28.40 percent (acenaphthylene for ROCH). CVs for only five pollutant-site combinations are greater than 15 percent.

The pollutant-specific average CV, as shown in orange in Table 31-12, ranges from 1.22 percent (phenanthrene) to 8.03 percent (benzo(k)fluoranthene). The site-specific average CV, as shown in green in Table 31-12, ranges from 1.98 percent (PXSS) to 5.84 percent (ANAK). The overall average analytical precision CV is 3.91 percent.

Sites at which collocated PAH samples were collected are highlighted in blue in Table 31-12 while sites at which replicates were run on individual samples are highlighted in brown. Collocated PAH samples were collected at only ANAK, DEMI, RUCA, SEWA, and SYFL; replicates were run on individual PAH samples at the remaining sites. The average CV for sites that collected collocated PAH samples was calculated and is shown in Table 31-12 in blue while the average CV for sites where replicates were run on individual samples is shown in brown. The variability ranges from 3.83 percent (replicates run on individual samples) to 4.15 percent (replicates run on collocated samples).

Table 31-13 presents analytical precision results for the 12 replicate analyses of select individual samples for KMMS, the only site for which PAH/Phenol samples were collected. The pollutant-specific average CV ranges from 0.96 percent (benzo(a)anthracene) to 8.93 percent (anthracene), with a site-specific average CV for KMMS of 3.16 percent.

**Table 31-12. PAH Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant**

Pollutant	ANAK	BOMA	BTUT	BXNY	CELA	CHSC	DEMI
Acenaphthene	6.70	3.61	3.42	7.03	4.91	4.73	5.22
Acenaphthylene	5.52	4.39	2.54	4.23	1.71	--	7.52
Anthracene	8.61	2.70	3.39	2.28	2.02	4.38	10.37
Benzo(a)anthracene	4.62	2.85	0.18	2.50	0.84	--	2.63
Benzo(a)pyrene	4.71	3.77	0.36	4.60	9.04	--	5.26
Benzo(b)fluoranthene	5.44	5.05	5.89	2.03	8.70	1.41	3.09
Benzo(e)pyrene	6.14	1.87	2.88	3.95	3.68	0.00	3.44
Benzo(g,h,i)perylene	5.42	6.59	9.12	2.30	4.20	2.01	4.52
Benzo(k)fluoranthene	13.93	17.50	9.37	5.95	3.84	--	4.78
Chrysene	8.90	2.19	9.81	1.91	3.07	9.71	1.36
Coronene	2.16	0.47	4.09	7.03	3.71	--	11.06
Cyclopenta[cd]pyrene	7.65	--	1.51	4.54	6.91	--	2.38
Dibenz(a,h)anthracene	3.81	--	--	--	3.04	--	4.60
Fluoranthene	4.98	3.34	1.81	5.49	4.37	3.42	2.55
Fluorene	4.56	2.67	6.41	6.38	3.31	2.85	1.63
9-Fluorenone	4.72	2.42	1.29	6.10	2.46	2.13	2.19
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	--	--
Naphthalene	4.95	4.19	5.95	3.87	1.98	1.08	3.25
Perylene	5.49	5.79	5.56	3.55	0.76		9.93
Phenanthrene	4.46	1.18	0.91	0.46	0.95	1.02	1.39
Pyrene	4.43	3.98	1.12	5.48	4.07	3.06	2.73
Retene	5.50	7.62	1.36	7.53	4.98	1.97	5.62
Average by Site	5.84	4.33	3.85	4.36	3.74	2.91	4.55
# of Pairs Collected per Site	18	4	4	4	4	6	15

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting collocated samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-12. PAH Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	GLKY	GPCO	LBHCA	NBIL	PRRI	PXSS	RIVA
Acenaphthene	4.25	3.39	2.59	6.66	3.03	5.60	1.75
Acenaphthylene	10.46	1.94	--	5.07	5.21	0.77	--
Anthracene	8.61	2.95	6.35	1.22	7.33	2.45	6.69
Benzo(a)anthracene	0.22	0.88	1.97	1.09	6.21	3.92	--
Benzo(a)pyrene	5.97	3.35	0.66	2.51	3.72	1.13	--
Benzo(b)fluoranthene	4.00	4.25	1.14	4.75	2.54	2.21	6.04
Benzo(e)pyrene	5.04	2.75	2.31	0.81	2.26	1.11	--
Benzo(g,h,i)perylene	2.02	4.05	5.66	0.77	3.38	0.16	--
Benzo(k)fluoranthene	11.01	5.84	--	1.51	9.25	1.78	--
Chrysene	4.57	2.10	6.73	5.68	3.22	3.50	12.43
Coronene	--	1.98	--	0.42	5.22	1.02	--
Cyclopenta[cd]pyrene	1.41	6.84	--	--	--	2.42	--
Dibenz(a,h)anthracene	--	7.16	3.81	--	2.76	0.96	--
Fluoranthene	2.24	2.96	2.07	5.42	2.90	0.99	2.09
Fluorene	2.00	2.05	1.97	4.23	1.47	0.52	0.84
9-Fluorenone	1.37	2.62	2.30	5.73	1.27	1.22	1.24
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	--	--
Naphthalene	2.14	2.88	5.15	3.49	4.35	1.23	1.27
Perylene	--	5.72	4.23	--	3.16	5.40	--
Phenanthrene	0.78	1.15	1.50	1.96	0.92	0.80	1.25
Pyrene	2.53	3.16	3.31	4.61	2.97	1.30	3.29
Retene	5.09	5.38	1.63	--	3.77	3.14	3.31
Average by Site	4.10	3.49	3.14	3.29	3.75	1.98	3.65
# of Pairs Collected per Site	5	8	3	4	6	4	4

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting collocated samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-12. PAH Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	ROCH	RUCA	S4MO	SEWA	SJJCA	SKFL	SYFL
Acenaphthene	2.29	9.53	1.28	2.54	3.71	4.77	1.37
Acenaphthylene	28.40	3.16	1.56	3.93	4.37	--	5.52
Anthracene	3.22	7.71	10.51	3.98	4.29	5.78	2.14
Benzo(a)anthracene	1.27	1.04	4.80	0.89	1.45	--	--
Benzo(a)pyrene	0.59	2.95	9.30	3.57	3.99	--	--
Benzo(b)fluoranthene	0.86	3.76	5.15	3.08	5.87	2.05	2.37
Benzo(e)pyrene	3.61	3.62	11.02	1.71	2.93	--	4.05
Benzo(g,h,i)perylene	6.09	3.24	8.40	5.67	3.67	6.15	4.38
Benzo(k)fluoranthene	18.57	0.26	6.35	8.42	15.13	--	--
Chrysene	2.37	4.11	3.49	2.69	4.28	0.70	7.15
Coronene	--	4.69	2.20	1.45	3.73	--	--
Cyclopenta[cd]pyrene	--	4.60	3.49	3.82	--	--	--
Dibenz(a,h)anthracene	--	8.72	11.92	2.58	--	--	--
Fluoranthene	0.34	2.22	1.40	2.37	1.39	2.97	1.00
Fluorene	1.07	1.75	2.21	3.17	15.84	2.54	1.14
9-Fluorenone	2.51	2.13	2.25	2.86	2.34	3.32	1.94
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	--	--
Naphthalene	1.95	5.78	4.47	3.52	4.73	3.49	3.67
Perylene	--	0.41	--	4.48	--	--	--
Phenanthrene	0.91	0.96	2.30	0.98	0.48	0.79	0.86
Pyrene	1.24	2.48	2.73	2.55	1.99	1.87	2.30
Retene	10.48	3.39	4.21	2.92	3.03	2.59	2.97
Average by Site	5.05	3.64	4.95	3.20	4.62	3.09	2.92
# of Pairs Collected per Site	3	13	7	14	4	1	7

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting collocated samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-12. PAH Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	UNVT	WADC	WPFL	# of Pairs	Average by Pollutant	Average for Collocated Pairs	Average for Unequipped
Acenaphthene	10.64	1.76	1.92	148	4.28	5.07	4.07
Acenaphthylene	5.50	7.72	1.48	92	5.55	5.13	5.69
Anthracene	3.10	4.62	2.56	119	4.89	6.56	4.45
Benzo(a)anthracene	--	0.00	4.11	57	2.18	2.30	2.15
Benzo(a)pyrene	--	2.69	--	68	3.79	4.12	3.69
Benzo(b)fluoranthene	2.16	4.87	2.96	115	3.74	3.55	3.79
Benzo(e)pyrene	--	1.61	--	81	3.24	3.79	3.06
Benzo(g,h,i)perylene	--	3.41	--	97	4.34	4.65	4.25
Benzo(k)fluoranthene	--	3.01	--	53	8.03	6.85	8.39
Chrysene	4.49	2.50	3.40	146	4.60	4.84	4.53
Coronene	--	1.74	--	50	3.40	4.84	2.87
Cyclopenta[cd]pyrene	--	--	--	29	4.14	4.61	3.87
Dibenz(a,h)anthracene	--	7.13	--	15	5.13	4.93	5.25
Fluoranthene	5.55	4.20	2.61	151	2.86	2.62	2.92
Fluorene	0.17	2.32	1.54	131	3.03	2.45	3.18
9-Fluorenone	4.08	2.60	1.82	151	2.62	2.77	2.58
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	--	--
Naphthalene	2.09	3.06	2.39	151	3.37	4.24	3.15
Perylene	--	--	--	21	4.54	5.08	4.27
Phenanthrene	0.89	0.98	1.37	151	1.22	1.73	1.08
Pyrene	4.05	3.82	1.69	151	2.95	2.90	2.96
Retene	--	3.43	2.33	96	4.19	4.08	4.23
Average by Site	3.88	3.24	2.32	2,073	3.91	4.15	3.83
# of Pairs Collected per Site	5	5	3				

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting collocated samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

Table 31-13. PAH/Phenols Analytical Precision: Coefficient of Variation Based on Replicate Analyses for KMMS

Pollutant	KMMS	# of Pairs	Average by Pollutant
Acenaphthene	2.41	12	2.41
Anthracene	8.93	7	8.93
Benzo(a)anthracene	0.96	1	0.96
Benzo(a)pyrene	--	--	--
Benzo(b)fluoranthene	2.18	1	2.18
Benzo(g,h,i)perylene	--	--	--
Benzo(k)fluoranthene	--	--	--
Chrysene	1.43	1	1.43
<i>m,p</i> -Cresols	1.57	12	1.57
<i>o</i> -Cresol	2.58	12	2.58
Dibenz(a,h)anthracene	--	--	--
Fluoranthene	4.94	12	4.94
Fluorene	3.29	12	3.29
Indeno(1,2,3-cd)pyrene	--	--	--
Naphthalene	1.48	12	1.48
Phenanthrene	3.41	12	3.41
Phenol	3.61	12	3.61
Pyrene	4.30	12	4.30
Average by Site	3.16	118	3.16
# of Pairs Collected per Site	12		

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV.

31.3.5 Metals Analytical Precision

Table 31-14 presents analytical precision results from replicate analyses of collocated and select individual samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the metals listed. The CVs exhibit low- to mid-level variability, ranging from 0 percent (for several sites and pollutants) to 31.19 percent (selenium for BTUT).

The pollutant-specific average CV, as shown in orange in Table 31-14, ranges from 1.42 percent (manganese) to 14.07 percent (mercury). The site-specific average CV, as shown in green in Table 31-14, ranges from 3.09 percent (TOOK) to 9.59 percent (BTUT). The overall average analytical precision CV is 5.98 percent.

Sites at which collocated metals samples were collected are highlighted in blue in Table 31-14 while sites at which replicates were run on individual samples are highlighted in brown. Collocated metals samples were collected at eight sites; replicates were run on individual PAH samples at the remaining 10 sites. The average CV for sites that collected collocated metals samples was calculated and is shown in Table 31-14 in blue while the average CV for sites where replicates were run on individual samples is shown in brown. The variability ranges from 5.48 percent (replicates run on individual samples) to 6.54 percent (replicates run on collocated samples).

**Table 31-14. Metals Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant**

Pollutant	ADOK	ASKY-M	BAKY	BOMA	BTUT
Antimony	1.37	0.98	1.20	1.22	1.44
Arsenic	1.76	6.16	11.01	18.98	7.87
Beryllium	8.89	17.67	17.38	14.14	24.59
Cadmium	6.66	4.15	7.34	8.68	5.95
Chromium	--	--	--	--	--
Cobalt	7.38	1.98	5.25	3.93	2.35
Lead	4.64	0.60	0.55	0.76	0.66
Manganese	2.26	0.51	0.98	1.13	1.74
Mercury	8.72	15.18	30.91	20.75	17.38
Nickel	--	1.04	4.60	2.94	2.70
Selenium	1.70	4.03	11.97	11.75	31.19
Average by Site	4.82	5.23	9.12	8.43	9.59
# of Pairs Collected per Site	2	12	6	57	12

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting collocated samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-14. Metals Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	CCKY	GLKY	LEKY	NBIL	OCOK
Antimony	2.02	2.00	0.55	5.16	2.60
Arsenic	16.87	18.55	12.40	4.25	3.43
Beryllium	0.00	0.00	--	7.67	4.80
Cadmium	15.36	10.86	8.36	2.61	11.82
Chromium	--	--	--	2.98	--
Cobalt	0.00	8.81	0.00	2.05	4.12
Lead	1.32	1.62	0.34	1.77	2.75
Manganese	0.48	1.45	0.53	1.28	1.89
Mercury	16.33	20.83	0.00	8.33	11.15
Nickel	5.24	15.11	3.53	--	--
Selenium	6.91	9.45	4.81	2.42	1.36
Average by Site	6.45	8.87	3.39	3.85	4.88
# of Pairs Collected per Site	4	60	4	24	4

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting collocated samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-14. Metals Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	PAFL	PXSS	S4MO	SEWA	SJJCA	TMOK
Antimony	0.59	0.20	1.33	1.40	0.92	5.56
Arsenic	3.42	18.60	13.75	22.12	13.09	5.31
Beryllium	15.71	12.61	7.56	--	0.00	10.41
Cadmium	11.96	2.95	4.35	7.64	13.23	9.59
Chromium	0.88	--	--	--	--	0.31
Cobalt	14.23	1.62	6.64	2.04	0.00	12.85
Lead	1.08	0.61	0.88	1.66	0.34	3.82
Manganese	2.84	1.24	0.95	1.20	0.56	3.67
Mercury	11.07	14.29	20.70	17.89	6.28	9.80
Nickel	--	1.86	4.87	2.72	1.63	0.44
Selenium	3.51	5.34	7.18	12.06	3.79	3.28
Average by Site	6.53	5.93	6.82	7.64	3.98	5.91
# of Pairs Collected per Site	6	4	116	5	5	4

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting colocated samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

**Table 31-14. Metals Analytical Precision: Coefficient of Variation
Based on Replicate Analyses by Site and Pollutant (Continued)**

Pollutant	TOOK	UNVT	# of Pairs	Average by Pollutant	Average for Collocated Pairs	Average for Unequipped
Antimony	1.46	1.59	443	1.75	1.90	1.64
Arsenic	2.07	20.88	399	11.14	11.56	10.80
Beryllium	6.77	--	173	9.88	11.20	8.73
Cadmium	3.45	11.98	445	8.16	6.50	9.49
Chromium	1.92	--	78	1.52	2.45	0.59
Cobalt	2.22	12.12	415	4.87	5.01	4.75
Lead	1.78	0.98	445	1.45	1.13	1.71
Manganese	1.71	1.13	445	1.42	1.24	1.56
Mercury	7.33	16.33	253	14.07	15.85	12.64
Nickel	3.08	3.43	318	3.80	4.74	2.86
Selenium	2.23	14.94	330	7.66	10.40	5.47
Average by Site	3.09	9.26	3,744	5.98	6.54	5.48
# of Pairs Collected per Site	108	12				

-- = No pairs with concentrations greater than or equal to the MDL.

Bold = CV greater than 15 percent

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Blue shading identifies sites collecting collocated samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

31.3.6 Hexavalent Chromium Analytical Precision

Table 31-15 presents analytical precision results from replicate analyses of collocated and select individual samples as the CV per site and the overall average CV for hexavalent chromium. The site-specific CV ranges from 3.89 percent (SEWA) to 18.13 percent (RIVA). CVs for only two of the 16 sites collecting hexavalent chromium samples are greater than 15 percent (PRRI and RIVA). The overall average analytical precision of hexavalent chromium is 8.53 percent, as shown in orange in Table 31-15. Note, however, that most sites sampling hexavalent chromium discontinued sampling this pollutant at the end of July 2013 and many of the precision calculations are based on relatively few pairs; precision for eight of the 16 sites is based on three or fewer samples.

Sites at which collocated hexavalent chromium samples were collected are highlighted in blue in Table 31-15 while sites at which replicates were run on individual samples only are highlighted in brown. Collocated samples were collected at 14 of the 16 sites listed in Table 31-15; replicates were run only on individual samples at MIWI and GLKY. The average CV for sites that collected collocated samples was calculated and is shown in Table 31-15 in blue while the average CV for sites where replicates were run on individual samples is shown in brown. The variability ranges from 7.98 percent (replicates run on individual samples) to 8.61 percent (replicates run on collocated samples).

Table 31-15. Hexavalent Chromium Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site

Site	CV (%)	# of Pairs
<i>BOMA</i>	8.84	4
<i>BTUT</i>	4.09	2
<i>BXNY</i>	8.08	6
<i>CAMS 35</i>	4.67	6
<i>DEMI</i>	8.46	4
<i>GLKY</i>	12.05	2
<i>GPCO</i>	5.29	2
MIWI	3.91	1
<i>NBIL</i>	5.11	2
<i>PRRI</i>	15.58	2
<i>PXSS</i>	13.01	6
<i>RIVA</i>	18.13	4
<i>S4MO</i>	6.10	8
<i>SDGA</i>	8.09	3
<i>SEWA</i>	3.89	2
<i>SKFL</i>	11.19	4
# of Pairs	58	
Average CV	8.53	
Average CV	8.61	
Average CV	7.98	

Bold = CV greater than 15 percent

Orange shading indicates the overall average CV for this method.

Blue shading identifies sites collecting collocated samples and brown shading identifies sites for which replicates were run on individual samples.

BOLD ITALICS = EPA-designated NATTS Site

31.4 Accuracy

Laboratories typically evaluate their accuracy (or bias) by analyzing audit samples that are prepared by an external source. The pollutants and the respective concentrations of the audit samples are unknown to the laboratory. The laboratory analyzes the samples and the external source compares the measured concentrations to the reference concentrations of those audit samples and calculates a percent difference. Accuracy, or bias, indicates the extent to which experimental measurements represent their corresponding “true” or “actual” values.

Laboratories participating in the NATTS program are provided with proficiency test (PT) audit samples for VOCs, carbonyl compounds, PAHs, metals, and hexavalent chromium, which are used to quantitatively measure analytical accuracy. Tables 31-16 through 31-20 present ERG’s results for PT audit samples analyzed in 2013. The program MQO for the percentage of the true value is ± 25 percent recovery, and the values exceeding this criterion are bolded in the tables. The calculation is as follows:

$$\text{Percent of True (\% Recovery)} = \frac{X_{lab}}{X_{true}} \times 100$$

Where:

X_{lab} is the analytical result from the laboratory;

X_{true} is the true concentration of the audit sample.

Note that the “true” value is based on the mean value of the referee laboratory’s results.

The results of the audit samples show that few of the pollutants for which audit samples were analyzed exceed the MQO for accuracy. Of the 74 results provided in Tables 31-16 through Table 31-20, only five exceed the ± 25 percent recovery MQO (two for VOCs and three for PAHs).

Table 31-16. TO-15 NATTS PT Audit Samples – Percent of True Value

Pollutant	January 2013	July 2013
Acrolein	87.7	91.8
Benzene	94.5	101.9
1,3-Butadiene	96.1	114.0
Carbon Tetrachloride	108.0	126.6
Chloroform	91.9	112.9
1,2-Dibromoethane	90.1	80.4
<i>cis</i> -1,3-Dichloropropene	107.0	83.1
<i>trans</i> -1,3-Dichloropropene	96.6	84.7
1,2-Dichloropropane	96.3	105.9
1,2-Dichloroethane	101.1	108.5
Dichloromethane	94.7	165.0
1,1,2,2-Tetrachloroethane	91.5	87.7
Tetrachloroethylene	91.0	89.4
Trichloroethylene	103.3	102.4
Vinyl chloride	88.4	101.2

Table 31-17. TO-11A NATTS PT Audit Samples – Percent of True Value

Pollutant	January 2013	July 2013
Acetaldehyde	96.4	103.8
Benzaldehyde	100.7	107.7
Formaldehyde	94.7	104.4
Propionaldehyde	86.0	97.1

Table 31-18. TO-13A NATTS PT Audit Sample – Percent of True Value

Pollutant	May 2013	December 2013
Acenaphthene	96.3	121.9
Anthracene	129.5	140.6
Benzo(a)pyrene	93.8	95.6
Fluoranthene	114.1	112.7
Fluorene	109.0	153.8
Naphthalene	124.6	NS
Phenanthrene	87.9	NS
Pyrene	114.5	112.3

NS = Not spiked onto PT audit sample provided to the laboratory

Table 31-19. Metals NATTS PT Audit Sample – Percent of True Value

Pollutant	May 2013	November 2013
Antimony	82.1	64.9
Arsenic	97.0	NS
Beryllium	98.0	90.1
Cadmium	101.4	98.4
Cobalt	102.4	91.3
Lead	100.1	94.8
Manganese	93.8	100.4
Nickel	98.8	NS
Selenium	84.4	NS

NS = Not spiked onto PT audit sample provided to the laboratory

Table 31-20. Hexavalent Chromium NATTS PT Audit Samples – Percent of True Value

Pollutant	May 2013	November 2013
Hexavalent Chromium	93.5	123.0

ERG's use of the ICP/MS was approved in 2012 as a FEM for the sampling and analysis of lead for adherence to the National Ambient Air Quality Standards (NAAQS) (EPA 2012a). This approval requires additional quality assurance steps, including the analysis of quarterly audit strips. Table 31-21 provides the results of the quarterly NAAQS audit results for lead for ERG. All results are within the ± 25 percent MQO.

Table 31-21. Metals NAAQS PT Audit Samples – Percent of True Value

Pollutant	Filter #	Analysis #	March 2013	May 2013	August 2013	December 2013
Lead	1	1	84.3	99.3	98.5	98.6
		2	85.2	98.3	94.6	102.0
		3	89.9	100.5	94.2	102.7
	2	1	87.8	98.6	99.1	98.7
		2	88.2	97.8	96.1	98.6
		3	89.6	93.7	96.8	97.5

The accuracy of the 2013 monitoring data can also be assessed qualitatively by reviewing the accuracy of the monitoring methods and how they were implemented:

- The sampling and analytical methods used in the 2013 monitoring effort have been approved by EPA for accurately measuring ambient levels of various pollutants - an approval that is based on many years of research into the development of ambient air monitoring methodologies.
- When collecting and analyzing ambient air samples, field sampling staff and laboratory analysts are required to strictly adhere to quality control and quality assurance guidelines detailed in the respective monitoring methods. This strict adherence to the well-documented sampling and analytical methods suggests that the 2013 monitoring data accurately represent ambient air quality.

32.0 Results, Conclusions, and Recommendations

The following discussion summarizes the results of the data analyses contained in this report, renders conclusions based on those results, and presents recommendations applicable to future air monitoring efforts. As demonstrated by the results of the data analyses discussed throughout this report, NMP data offer a wealth of information for assessing air quality by evaluating trends, patterns, correlations, and the potential for health risk. NMP data should ultimately assist a wide range of audiences understand the complex nature of air pollution.

32.1 Summary of Results

Analyses of the 2013 monitoring data identified the following notable results, observations, trends, and patterns in the program-level and state- and site-specific air monitoring data.

32.1.1 Program-level Results Summary

- *Number of participating sites.* Twenty-five of the 66 monitoring sites are EPA-designated NATTS sites. An additional 39 UATMP sites participated in the NMP in 2013. Data from two CSATAM sites (ANAK and LBHCA) are also included in the 2013 NMP report.
- *Total number of samples collected and analyzed.* Over 9,400 valid samples were collected by program participants and analyzed at the ERG laboratory, yielding nearly 263,000 valid measurements of air toxics, including duplicate, collocated, and replicate results.
- *Detects.* Of the 175 pollutants monitored, 165 pollutants were detected at least once over the course of the 2013 monitoring effort. The detection of a given pollutant is subject to the sensitivity limitation associated with the analytical methods used and the limitations of the instruments. Simply stated, an MDL is the lowest concentration of a target pollutant that can be measured and reported with 99 percent confidence that the pollutant concentration is greater than zero. Approximately 53 percent of the reported measurements were greater than the associated MDLs. At the method level, this percentage varies considerably, from 39 percent for hexavalent chromium to 83 percent for carbonyl compounds. Quantification below the MDL is possible and an acceptable analytical result; therefore, these results are incorporated into the data analyses. These measurements account for 9 percent of concentrations. Non-detects account for the remaining 38 percent of results.
- *Program-level Pollutants of Interest.* The pollutants of interest at the program-level are based on the total number of concentrations greater than the risk screening value, or those “failing the screen”. Thirty-eight pollutants failed at least one risk screening value; of those pollutants, 13 were identified as program-level pollutants of interest.

- *Mobile Sources.* Site-specific hydrocarbon concentrations had virtually no correlations with county-level motor vehicle ownership data, traffic data, and VMT data in this year's report. This is a slight change from previous years' reports when most of the correlations were positive, albeit weak.
- *Seasonal Trends.* Formaldehyde concentrations tended to be highest during the warmer months of the year. Acenaphthene and acetaldehyde concentrations exhibit a similar pattern. Conversely, benzene and 1,3-butadiene concentrations tended to be higher during the colder months of the year.

32.1.2 State-level Results Summary

Alaska.

- The Alaska monitoring site (ANAK) is located in Anchorage and is a CSATAM site.
- VOCs and PAHs were sampled for at ANAK.
- Twelve pollutants failed screens for ANAK, of which eight were identified as pollutants of interest. Benzene and carbon tetrachloride were detected in every valid sample and failed 100 percent of screens.
- Of the pollutants of interest for ANAK, benzene has the highest annual average concentration and is the only pollutant with an annual average greater than 1 $\mu\text{g}/\text{m}^3$.
- ANAK has the second highest annual average concentrations of benzene and ethylbenzene among NMP sites sampling this pollutant.
- Benzene has the highest cancer risk approximation for ANAK, followed by 1,3-butadiene and carbon tetrachloride. None of the noncancer hazard approximations for ANAK are greater than 1.0 in-a-million.
- Formaldehyde is the highest emitted pollutant with a cancer toxicity factor in Anchorage, and also has the highest cancer toxicity-weighted emissions. Toluene is the highest emitted pollutant with a noncancer toxicity factor in Anchorage, while acrolein has the highest noncancer toxicity-weighted emissions.

Arizona.

- The Arizona monitoring sites are located in Phoenix. PXSS is a NATTS site; SPAZ is a UATMP site.
- VOCs, carbonyl compounds, PAHs, metals (PM_{10}), and hexavalent chromium were sampled for at PXSS, although hexavalent chromium sampling was discontinued in June. VOCs were sampled for at SPAZ.
- Eighteen pollutants failed screens for PXSS, 10 of which contributed to 95 percent of failed screens. PXSS failed the second highest number of screens among all NMP

sites. Six pollutants failed screens for SPAZ, all of which contributed to 95 percent of failed screens.

- Of the pollutants of interest for PXSS, formaldehyde has the highest annual average concentration, followed by acetaldehyde and benzene. These are the only pollutants of interest with annual average concentrations greater than 1 µg/m³.
- Benzene has the highest annual average concentration for SPAZ, and is the only pollutant with an annual average concentration greater than 1 µg/m³.
- SPAZ and PXSS have the highest annual average concentrations of *p*-dichlorobenzene among NMP sites sampling this pollutant.
- Sampling for the site-specific pollutants of interest has occurred at PXSS and SPAZ for at least 5 consecutive years; thus, a trends analysis was conducted for each site for the site-specific pollutants of interest. Benzene concentrations measured at both sites have decreased over recent years. Arsenic concentrations have also decreased at PXSS in recent years. The detection rate of 1,2-dichloroethane at both sites has been steadily increasing over the years, with a significant increase for 2012, which continued in 2013.
- Formaldehyde has the highest cancer risk approximation for PXSS and is the only pollutant of interest with a cancer risk approximation greater than 10 in-a-million for either site. Benzene has the highest cancer risk approximation for SPAZ. None of the pollutants of interest for either site have a noncancer hazard approximation greater than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Maricopa County, while toluene is the highest emitted pollutant with a noncancer toxicity factor. Formaldehyde has the highest cancer toxicity-weighted emissions, while acrolein has the highest noncancer toxicity-weighted emissions for Maricopa County.

California.

- The four California monitoring sites are located in Los Angeles (CELA), Long Beach (LBHCA), Rubidoux (RUCA), and San Jose (SJJCA). CELA, RUCA, and SJJCA are NATTS sites; LBHCA is a CSATAM site.
- PAHs were sampled for at CELA, LBHCA, and RUCA. PAHs and metals (PM₁₀) were sampled for at SJJCA. Sampling at LBHCA was discontinued in July 2013 at the end of a 1-year monitoring effort.
- Naphthalene failed the majority of screens for CELA, LBHCA, and RUCA. Naphthalene and arsenic contributed almost equally to the total number of failed screens for SJJCA, together accounting for more than 85 percent of failed screens for the site.

- Naphthalene has the highest annual average concentration for CELA, RUCA, and SJJCA. Annual average concentrations could not be calculated for LBHCA because sampling ended in July.
- Sampling for the site-specific pollutants of interest has occurred at CELA, RUCA, and SJJCA for at least 5 consecutive years; thus, a trends analysis was conducted for each site for the site-specific pollutants of interest. Concentrations of fluorene and naphthalene decreased significantly from 2012 levels at CELA. Concentrations of the pollutants of interest for RUCA have not changed significantly over the last few years. Concentrations of arsenic have a slight increasing trend at SJJCA over the last several years, particularly for 2013.
- Of the pollutants of interest for each site, naphthalene has the highest cancer risk approximation for all three California sites. The noncancer hazard approximations for each pollutant of interest are considerably less than an HQ of 1.0 for all three sites. Cancer risk and noncancer hazard approximations could not be calculated for LBHCA.
- Formaldehyde is the highest emitted pollutant with a cancer toxicity factor in Los Angeles and Riverside Counties, while benzene is the highest emitted pollutant with a cancer toxicity factor in Santa Clara County. Formaldehyde has the highest cancer toxicity-weighted emissions for all three counties.
- Toluene is the highest emitted pollutant with a noncancer toxicity factor in Los Angeles, Riverside, and Santa Clara Counties, while acrolein has the highest noncancer toxicity-weighted emissions for all three counties.

Colorado.

- The NATTS site in Colorado is located in Grand Junction (GPCO). There are also five UATMP sites located northeast of Grand Junction in Garfield County. The sites are located in the towns of Battlement Mesa (BMCO), Silt (BRCO), Parachute (PACO), Carbondale (RFCO), and Rifle (RICO).
- VOCs, carbonyl compounds, PAHs, and hexavalent chromium were sampled for at GPCO, although hexavalent chromium sampling was discontinued in June. SNMOCs and carbonyl compounds were sampled for at the Garfield County sites.
- Fifteen pollutants failed at least one screen for GPCO, 12 of which contributed to 95 percent of failed screens. Five pollutants failed screens for four of the Garfield County sites (BMCO, BRCO, PACO, and RICO), while four pollutants failed screens for RFCO. Benzene, formaldehyde, and acetaldehyde were identified as pollutants of interest for all five Garfield County sites as well as GPCO.
- Of the pollutants of interest for GPCO, formaldehyde has the highest annual average concentration, followed by acetaldehyde.

- Benzene has the highest annual average concentration for each of the Garfield County sites except RFCO, where formaldehyde has the highest annual average concentration. Annual average concentrations could not be calculated for carbonyl compounds for RICO due to low sampling completeness.
- PACO has the highest annual average concentration of benzene among NMP sites. GPCO has the second highest annual average concentrations of acetaldehyde, formaldehyde, and naphthalene among NMP sites sampling these pollutants.
- Sampling for the site-specific pollutants of interest has occurred at GPCO, BRCO, PACO, and RICO for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Benzene concentrations at GPCO have an overall decreasing trend across the years of sampling. Conversely, acetaldehyde concentrations at GPCO have been increasing in recent years. In addition, the detection rate of 1,2-dichloroethane at GPCO has been increasing steadily over the last few years of sampling, particularly for 2012. Distinct trends were difficult to identify for the Garfield County sites due to variability in the measurements and annual averages that could not be calculated for one or more years. However, benzene concentrations measured at BRCO, PACO, and RICO exhibit a decreasing trend through 2012 followed by a considerable increase for 2013.
- Formaldehyde has the highest cancer risk approximation for GPCO (by an order of magnitude) and is the third highest cancer risk approximation calculated across the program for 2013. Formaldehyde and benzene have the highest cancer risk approximation for each of the Colorado sites, where an annual average could be calculated. All noncancer hazard approximations are less than an HQ of 1.0 for all of the Colorado sites, where noncancer hazard approximations could be calculated.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in both Mesa and Garfield Counties, while formaldehyde has the highest cancer toxicity-weighted emissions for both counties.
- While toluene is the highest emitted pollutant with a noncancer toxicity factor for both Mesa and Garfield Counties, acrolein has the highest noncancer toxicity-emissions for both counties.

District of Columbia.

- The Washington, D.C. monitoring site (WADC) is a NATTS site.
- PAHs and hexavalent chromium were sampled for at WADC, although hexavalent chromium sampling was discontinued in June.
- Naphthalene accounted for nearly 97 percent of failed screens for this site and was the only pollutant identified as a pollutant of interest.

- Naphthalene was detected in every valid PAH sample collected at WADC. The annual average concentration of naphthalene for WADC is the ninth highest annual average concentration among NMP sites sampling this pollutant.
- Sampling for the site-specific pollutants of interest has occurred at WADC for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Concentrations of naphthalene have decreased since 2009 at WADC.
- The cancer risk approximation for naphthalene is 2.83 in-a-million. The noncancer hazard approximation for naphthalene is considerably less than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in the District of Columbia, while toluene is the highest emitted pollutant with a noncancer toxicity factor. Formaldehyde has the highest cancer toxicity-weighted emissions, while acrolein has the highest noncancer toxicity-weighted emissions in the District.

Florida.

- Three of the Florida monitoring sites are located in the Tampa-St. Petersburg-Clearwater CBSA (SYFL, AZFL, and SKFL) and two are located in the Orlando-Kissimmee-Sanford CBSA (ORFL and PAFL). WPFL is located on the western edge of the Miami-Ft. Lauderdale-West Palm Beach CBSA. SKFL and SYFL are NATTS sites while the other four are UATMP sites.
- Carbonyl compounds were sampled for at AZFL and ORFL. Hexavalent chromium and PAHs were sampled for at SKFL and SYFL in addition to carbonyl compounds. However, hexavalent chromium sampling was discontinued at SKFL in June and sampling for both PAHs and hexavalent chromium was discontinued at SYFL in June. Metals (PM₁₀) were sampled for at PAFL. PAHs were sampled for at WPFL during a 1-year monitoring effort between March 2013 and March 2014. The 2014 data for WPFL are included in the Florida section but excluded from most program-level analyses.
- Acetaldehyde and formaldehyde failed screens for all four Florida sites sampling carbonyl compounds. Naphthalene failed screens for all three Florida sites that sampled PAHs. Three additional PAHs failed screens for WPFL. Hexavalent chromium failed a single screen for SKFL. Arsenic failed 100 percent of screens for PAFL.
- Formaldehyde has the highest annual average concentration for the four Florida sites sampling carbonyl compounds, although the annual average concentrations of acetaldehyde were just slightly lower. Naphthalene has the highest annual average concentration for WPFL. PAFL's annual average arsenic concentration ranks sixth highest among NMP sites sampling metals (PM₁₀).
- Sampling for the site-specific pollutants of interest has occurred at all of the Florida sites except WPFL for at least 5 consecutive years; thus, a trends analysis was

conducted for the site-specific pollutants of interest. The following notable observations regarding trends include: While acetaldehyde concentrations have been variable at AZFL, formaldehyde concentrations have changed little over the last few years. Acetaldehyde concentrations have leveled off after decreasing over the last few years at SKFL. Formaldehyde concentrations decreased considerably at SKFL from 2012 to 2013. Formaldehyde concentrations measured in 2013 at SYFL exhibit the least amount of variability over the 10 years of sampling. Formaldehyde concentrations have changed little at ORFL in the last few years while acetaldehyde concentrations have exhibited more variability.

- For the four Florida sites sampling carbonyl compounds, formaldehyde has the highest cancer risk approximations, ranging from 20 in-a-million to 25 in-a-million. The cancer risk approximation for arsenic for PAFL is 3.10 in-a-million. Naphthalene has the highest cancer risk approximation for WPFL, although this was one of the lowest cancer risk approximations for naphthalene among NMP sites sampling PAHs. All noncancer hazard approximations for the pollutants of interest for the Florida sites are less than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Pinellas, Hillsborough, and Orange Counties, while formaldehyde is the highest emitted pollutant with a cancer toxicity factor in Palm Beach County. Benzene has the highest cancer toxicity-weighted emissions for Pinellas County; formaldehyde has the highest cancer toxicity-weighted emissions for Hillsborough and Palm Beach Counties; and hexavalent chromium has the highest cancer toxicity-weighted emissions for Orange County.
- Toluene is the highest emitted pollutant with a noncancer toxicity factor in all four Florida counties. Acrolein has the highest noncancer toxicity-weighted emissions for all four counties.

Georgia.

- The SDGA monitoring site located in Decatur, east of Atlanta, is a NATTS site.
- Hexavalent chromium was sampled for at SDGA, although sampling under the NMP was discontinued in July.
- Hexavalent chromium was detected in eight of the 30 valid samples collected at SDGA in 2013, with measured detections of hexavalent chromium ranging from 0.0068 ng/m³ to 0.103 ng/m³.
- Of eight measured detections, hexavalent chromium failed only one screen.
- An annual average concentration could not be calculated for hexavalent chromium since sampling ended in mid-July.
- Sampling for the site-specific pollutants of interest has occurred at SDGA for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific

pollutants of interest. This analysis shows that the range of concentrations of hexavalent chromium measured at SDGA have not changed significantly over the last few years of sampling.

- Benzene is the highest emitted pollutant with a cancer toxicity factor in DeKalb County, while formaldehyde has the highest cancer toxicity-weighted emissions. Toluene is the highest emitted pollutant with a noncancer toxicity factor, while acrolein has the highest noncancer toxicity-weighted emissions for DeKalb County.

Illinois.

- Two Illinois monitoring sites are located near Chicago. NBIL is a NATTS site located in Northbrook and SPIL is a UATMP site located in Schiller Park. A third site, ROIL, is located in Roxana, on the Illinois border near St. Louis.
- VOCs and carbonyl compounds were sampled for at all three Illinois sites. SNMOCs, PAHs, hexavalent chromium, and metals (PM₁₀) were also sampled for at NBIL. NBIL is one of only two NMP sites sampling all six pollutant groups, although hexavalent chromium sampling was discontinued in June.
- Twenty pollutants failed screens for NBIL; 12 pollutants failed screens for SPIL; and 11 pollutants failed screens for ROIL.
- Of the pollutants of interest for each site, acetaldehyde and formaldehyde are the only pollutants with annual average concentrations greater than 1 µg/m³. Acetaldehyde has the highest annual average concentration for NBIL, while formaldehyde has the highest annual average concentration for SPIL and ROIL.
- NBIL has highest annual average concentrations of acenaphthene and naphthalene among NMP sites sampling PAHs. The maximum concentrations of acetaldehyde and trichloroethylene program-wide were measured at SPIL.
- Sampling for the site-specific pollutants of interest has occurred at NBIL and SPIL for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Most notably, concentrations of acetaldehyde have increased significantly at NBIL in recent years. In addition, the detection rate of 1,2-dichloroethane at both NBIL and SPIL has been increasing steadily over the last few years of sampling.
- Formaldehyde has the highest cancer risk approximation for all three Illinois sites. All noncancer hazard approximations for the pollutants of interest for the Illinois sites are less than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Cook County, while formaldehyde has the highest cancer-toxicity weighted emissions. Formaldehyde is the highest emitted pollutant with a cancer toxicity factor in Madison County, while coke oven emissions (PM) have the highest cancer toxicity emissions.

- Toluene is the highest emitted pollutant with a noncancer toxicity factor for both counties, while acrolein has the highest noncancer toxicity-weighted emissions for both counties.

Indiana.

- There are two Indiana monitoring sites, one located in Indianapolis (WPIN) and a second located in Gary, near Chicago (INDEM). Both are UATMP sites.
- Carbonyl compounds were sampled for at WPIN and INDEM.
- Formaldehyde and acetaldehyde failed screens for both INDEM and WPIN; all of the measured detections of formaldehyde failed screens for both sites.
- Formaldehyde has the highest annual average concentration for both sites, although concentrations were higher at WPIN than INDEM. WPIN's annual average concentration of formaldehyde is the sixth highest annual average concentration of this pollutant among NMP sites sampling carbonyl compounds.
- Sampling for the site-specific pollutants of interest has occurred at WPIN and INDEM for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Concentrations of acetaldehyde have decreased at WPIN in the last few years. Concentrations of formaldehyde and acetaldehyde exhibited a significant decreasing trend at INDEM from 2008 to 2009, which may be at least partially explained by a sampler change.
- The cancer risk approximations for formaldehyde are an order of magnitude greater than the cancer risk approximations for acetaldehyde for both sites. The noncancer hazard approximations for the pollutants of interest for the Indiana sites are less than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in both Marion and Lake Counties. Coke oven emissions (PM) have the highest cancer toxicity-weighted emissions for Lake County while formaldehyde has the highest cancer toxicity-weighted emissions for Marion County.
- Toluene is the highest emitted pollutant with a noncancer toxicity factor in both Lake and Marion Counties while acrolein has the highest noncancer toxicity-weighted emissions for both counties.

Kentucky.

- Three Kentucky monitoring sites are located in northeast Kentucky, two in Ashland (ASKY and ASKY-M) and one near Grayson Lake (GLKY). The Grayson Lake monitoring site is a NATTS site. One monitoring site is located south of Evansville, Indiana (BAKY). Five monitoring sites are located in or near the Calvert City area

(ATKY, CCKY, BLKY, LAKY, and TVKY). The final monitoring site is located in Lexington, in north-central Kentucky (LEKY).

- All of the Kentucky monitoring sites sampled for VOCs except ASKY-M and BAKY. PAHs, carbonyl compounds, PM₁₀ metals, and hexavalent chromium were also sampled for at GLKY, although hexavalent chromium sampling was discontinued in June. Carbonyl compounds were also sampled for at ASKY and LEKY and PM₁₀ metals were also sampled for at ASKY-M, BAKY, CCKY, and LEKY.
- The number of pollutants failing screens for the Kentucky sites varies from two (BAKY) to 12 (LEKY, TVKY, and GLKY).
- Of the pollutants of interest for each site, formaldehyde has the highest annual average concentration for all three sites sampling carbonyl compounds (GLKY, ASKY, and LEKY). Manganese has the highest annual average concentration for ASKY-M, while arsenic has the highest annual average concentration for BAKY. Carbon tetrachloride has the highest annual average concentration for ATKY and CCKY, while 1,2-dichloroethane has the highest annual average concentration for BLKY, LAKY, and TVKY.
- The annual average concentrations of arsenic and nickel calculated for ASKY-M are the highest annual average concentrations among NMP sites sampling PM₁₀ metals. BAKY, LEKY, and CCKY are also among the NMP sites with highest annual average concentrations of arsenic. ASKY has the fourth highest annual average concentration of benzene among NMP sites sampling benzene; in addition, the maximum concentration of benzene among all sites sampling VOCs was measured at ASKY.
- The Calvert city sites measured some of the highest concentrations of some VOCs, particularly vinyl chloride, 1,2-dichloroethane, 1,3-butadiene, and carbon tetrachloride.
- The highest cancer risk approximations among the pollutants of interest for the Kentucky sites were calculated for 1,2-dichloroethane (TVKY, 97.42 in-a-million and BLKY, 33.15 in-a-million), formaldehyde (LEKY, 37.85 in-a-million), and 1,3-butadiene (TVKY, 30.97 in-a-million). The cancer risk approximation for TVKY for 1,2-dichloroethane is the second highest cancer risk approximation calculated among the site-specific pollutants of interest. None of the pollutants of interest for which noncancer hazard approximations could be calculated were greater than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in all Kentucky counties with NMP sites, except Henderson County, where benzene ranks second to formaldehyde. Coke oven emissions have the highest cancer toxicity-weighted emissions for Boyd County; formaldehyde has the highest cancer toxicity-weighted emissions for Carter, Henderson, Livingston, and Fayette Counties; and benzene has the highest cancer toxicity-weighted emissions for Marshall County.

- Toluene is the highest emitted pollutant with a noncancer toxicity factor in Boyd, Carter, Livingston, and Fayette Counties; carbonyl sulfide is the highest emitted pollutant with a noncancer toxicity factor in Henderson County; and methanol is the highest emitted pollutant with a noncancer toxicity factor in Marshall County. Acrolein has the highest noncancer toxicity-weighted emissions in five of the Kentucky counties, but ranks second to chlorine in Marshall County.

Massachusetts.

- The Massachusetts monitoring site (BOMA) is a NATTS site located in Boston.
- Metals (PM₁₀), PAHs, and hexavalent chromium were sampled for at BOMA, although hexavalent chromium sampling was discontinued in June.
- Seven pollutants failed screens for BOMA. Arsenic and naphthalene each accounted for at least 40 percent of the site's failed screens.
- Of the pollutants of interest, naphthalene has the highest annual average concentration.
- BOMA has the fifth highest annual average concentration of nickel among NMP sites sampling PM₁₀ metals.
- Sampling for the site-specific pollutants of interest has occurred at BOMA for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Concentrations of the pollutants of interest for BOMA exhibit little change over recent years of sampling.
- The pollutants of interest for BOMA with cancer risk approximations greater than 1.0 in-a-million are arsenic and naphthalene. None of the pollutants of interest for BOMA have noncancer hazard approximations greater than an HQ of 1.0.
- Formaldehyde is the highest emitted pollutant with a cancer toxicity factor in Suffolk County and has the highest cancer toxicity-weighted emissions. Toluene is the highest emitted pollutant with a noncancer toxicity factor in Suffolk County, while acrolein has the highest noncancer toxicity-weighted emissions.

Michigan.

- The Michigan monitoring site (DEMI) is a NATTS site located in Dearborn, southwest of Detroit.
- VOCs, carbonyl compounds, PAHs, and hexavalent chromium were sampled for at DEMI, although hexavalent chromium sampling was discontinued in June.
- Eighteen pollutants failed screens for DEMI, of which 10 were identified as pollutants of interest.

- Formaldehyde and acetaldehyde have the highest annual average concentrations for DEMI. Compared to other NMP sites sampling PAHs, the annual average concentration of acenaphthene for DEMI is the third highest while this site's annual average concentration of naphthalene ranks fifth highest.
- Sampling for the site-specific pollutants of interest has occurred at DEMI for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Benzene concentrations exhibit a steady decreasing trend although concentrations have leveled out in recent years. In addition, the detection rate of 1,2-dichloroethane at DEMI has been increasing steadily over the last few years of sampling.
- Formaldehyde has the highest cancer risk approximation for DEMI. None of the pollutants of interest for DEMI had noncancer hazard approximations greater than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Wayne County, while coke oven emissions have the highest cancer toxicity-weighted emissions. Hydrochloric acid is the highest emitted pollutant with a noncancer toxicity factor in Wayne County, while acrolein has the highest noncancer toxicity-weighted emissions.

Minnesota.

- The UATMP site in Minnesota (STMN) is located in St. Cloud.
- Hexavalent chromium was sampled for at STMN through the end of May 2013 as part of a 1-year monitoring effort that began in February 2012.
- Twenty-four samples were collected at STMN in 2013 before sampling concluded; measured detections of hexavalent chromium range from 0.008 ng/m³ to 0.039 ng/m³, and includes 16 non-detects.
- Concentrations of hexavalent chromium did not fail any screens for STMN.
- Formaldehyde is the highest emitted pollutant with a cancer toxicity factor in Stearns County and has the highest cancer toxicity-weighted emissions. Toluene is the highest emitted pollutant with a noncancer toxicity factor in Stearns County, while acrolein has the highest noncancer toxicity-weighted emissions.

Mississippi.

- The Mississippi monitoring sites (KMMS and SSMS) are UATMP sites located in Columbus.
- Both KMMS and SSMS sampled for VOCs. KMMS also sampled for PAHs between May and October, with an adjusted methodology that included phenols and cresols.

- Fourteen pollutants failed screens for KMMS, with 10 pollutants contributing to 95 percent of the total failed screens. Ten pollutants failed screens for SSMS, with seven pollutants contributing to 95 percent of the total failed screens. KMMS is the only NMP site for which xylenes were identified as a pollutant of interest.
- Xylenes have the highest annual average concentration for KMMS, while carbon tetrachloride has the highest annual average for SSMS.
- KMMS has the highest annual average concentration of ethylbenzene among NMP sites sampling this pollutant. SSMS has the highest annual average concentration of hexachloro-1,3-butadiene among NMP sites.
- Ethylbenzene and benzene have the highest cancer risk approximations for KMMS. Benzene has the highest cancer risk approximation for SSMS. None of the pollutants of interest for either site have a noncancer hazard approximation greater than an HQ of 1.0.
- Ethylbenzene is the highest emitted pollutant with a cancer toxicity factor in Lowndes County, while formaldehyde has the highest cancer toxicity-weighted emissions. Methanol is the highest emitted pollutant with a noncancer toxicity factor in Lowndes County, while acrolein has the highest noncancer toxicity-weighted emissions.

Missouri.

- The NATTS site in Missouri (S4MO) is located in St. Louis.
- VOCs, carbonyl compounds, PAHs, metals (PM₁₀), and hexavalent chromium were sampled for at S4MO.
- Twenty-one pollutants failed at least one screen for S4MO, 15 of which contributed to 95 percent of failed screens. S4MO failed the greatest number of screens among NMP sites.
- Of the pollutants of interest for S4MO, formaldehyde and acetaldehyde have the highest annual average concentrations and are the only pollutants with annual average concentrations greater than 1 µg/m³.
- S4MO has the second highest annual average concentration of hexachloro-1,3-butadiene, the fourth highest annual average concentration of *p*-dichlorobenzene, and the fifth highest annual average concentration of arsenic (PM₁₀) among NMP sites sampling these pollutants.
- Sampling for the site-specific pollutants of interest has occurred at S4MO for at least 5 consecutive years; thus, a trends analysis was conducted for each of the site-specific pollutants of interest. Most notably, acetaldehyde concentrations have decreased significantly since 2010. Some of the lowest concentrations of pollutants such as arsenic, *p*-dichlorobenzene, and naphthalene were measured in 2013. The detection

rate of 1,2-dichloroethane has been increasing at S4MO over the last few years of sampling.

- Formaldehyde has the highest cancer risk approximation for S4MO. None of the pollutants of interest for S4MO have a noncancer hazard approximation greater than an HQ of 1.0.
- Formaldehyde is the highest emitted pollutant with a cancer toxicity factor in St. Louis (city) and has the highest cancer toxicity-weighted emissions. Toluene is the highest emitted pollutant with a noncancer toxicity factor, while acrolein has the highest noncancer toxicity-weighted emissions in St. Louis (city).

New Jersey.

- Three of the UATMP sites in New Jersey are located in the New York-Newark-Jersey City CBSA in the towns of Chester (CHNJ), Elizabeth (ELNJ), and North Brunswick (NBNJ). A fourth UATMP site (CSNJ) is located in the Philadelphia-Camden-Wilmington CBSA and is sampling under the NMP for the first time.
- VOCs and carbonyl compounds were sampled for at all four New Jersey sites.
- Sixteen pollutants failed at least one screen for CSNJ; nine pollutants failed at least one screen for CHNJ; and 11 pollutants failed at least one screen for both ELNJ and NBNJ, although the pollutants differed somewhat.
- Of the site-specific pollutants of interest, formaldehyde and acetaldehyde have the highest annual average concentrations for each New Jersey site.
- The annual average concentrations of hexachloro-1,3-butadiene for NBNJ, CSNJ, and CHNJ rank third, fifth, and sixth, respectively, among NMP sites sampling VOCs. CSNJ has the third highest annual average concentration of both acetaldehyde and formaldehyde, while ELNJ has the fourth highest annual average concentration of formaldehyde and fifth highest annual average concentration of acetaldehyde among NMP sites sampling carbonyl compounds.
- Sampling for the site-specific pollutants of interest has occurred at three of the four New Jersey sites for at least 5 consecutive years; specifically, ELNJ is the longest running NMP site still participating in the NMP. As such, a trends analysis was conducted for the site-specific pollutants of interest. Benzene and ethylbenzene concentrations have decreased significantly at ELNJ since sampling began. In addition, the detection rates of 1,2-dichloroethane and hexachloro-1,3-butadiene have been increasing steadily over the last few years of sampling at CHNJ, ELNJ, and NBNJ.
- Formaldehyde has the highest cancer risk approximation for each of the New Jersey sites. None of the pollutants of interest for any of the New Jersey sites have noncancer hazard approximations greater than an HQ of 1.0.

- Benzene and formaldehyde are the highest emitted pollutants with cancer UREs in Camden, Union, Middlesex, and Morris Counties. These two pollutants also have the highest toxicity-weighted emissions for each county, although the order varied.
- Toluene is the highest emitted pollutant with a noncancer toxicity factor in Camden, Union, Middlesex, and Morris Counties. Acrolein has the highest noncancer toxicity-weighted emissions for each New Jersey county.

New York.

- The New York monitoring sites are located in New York City (BXNY) and Rochester (ROCH). Both are NATTS sites.
- PAHs and hexavalent chromium were sampled for at both BXNY and ROCH, although hexavalent chromium sampling was discontinued at BXNY in June and at ROCH in July.
- Six pollutants failed screens for BXNY and four pollutants failed screens for ROCH. Naphthalene failed the majority of screens for both sites.
- Naphthalene has the highest annual average concentration for BXNY and ROCH, although the annual average concentration for BXNY is twice the annual average calculated for ROCH.
- ROCH and BXNY have the second and fifth highest annual average concentrations of acenaphthene, respectively, among NMP sites sampling PAHs. BXNY also has the third highest annual average concentration of naphthalene among NMP sites.
- Even though sampling of PAHs has been conducted at ROCH for greater than 5 consecutive years, a sample collection error resulted in the invalidation of a year and a half's worth of data. Although a trends analysis was conducted for each of the site-specific pollutants of interest for ROCH, the gap in data makes definitive trends hard to identify.
- Naphthalene has the highest cancer risk approximation among the pollutants of interest for both ROCH and BXNY. None of the pollutants of interest for either site have noncancer hazard approximations greater than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor for Bronx and Monroe Counties while formaldehyde has the highest cancer toxicity-weighted emissions for both counties.
- Toluene is the highest emitted pollutant with a noncancer toxicity factor in both Bronx and Monroe Counties. Acrolein has the highest noncancer toxicity-weighted emissions for both counties.

Oklahoma.

- There are five UATMP sites in Oklahoma: three located in Tulsa (TOOK, TMOK, and TROK) and two in Oklahoma City (ADOK and OCOK). The sampling instrumentation at ADOK was moved mid-year to a site west of Oklahoma City in Yukon (YUOK).
- VOCs, carbonyls compounds, and metals (TSP) were sampled for at each of the Oklahoma sites.
- Seventeen pollutants failed screens for TOOK; 15 failed screens for TMOK; 14 failed screens for TROK; 12 failed screens for ADOK; 16 failed screens for OCOK; and 11 failed screens for YUOK.
- Formaldehyde and acetaldehyde have the highest annual average concentrations for TOOK, TMOK, TROK, and OCOK. Annual average concentrations could not be calculated for ADOK and YUOK due to the mid-year relocation of the instruments.
- TMOK has the third highest annual average concentration of *p*-dichlorobenzene among NMP sites sampling this pollutant. OCOK has the fourth highest annual average concentration of hexachloro-1,3-butadiene among NMP sites sampling this pollutant.
- Sampling for the site-specific pollutants of interest has occurred at TOOK, TMOK, and OCOK for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. After several years of increasing, acetaldehyde, ethylbenzene, and manganese concentrations decreased at TOOK for 2013. Benzene concentrations at TOOK and TMOK have decreased in recent years, while acetaldehyde and formaldehyde concentrations at OCOK have also decreased. Detection rates of 1,2-dichloroethane and hexachloro 1,3-butadiene have increased at TOOK, TMOK, and OCOK in recent years.
- Formaldehyde and benzene have the highest cancer risk approximations for all of the Oklahoma monitoring sites. None of the pollutants of interest for the Oklahoma sites have a noncancer hazard approximation greater than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Oklahoma and Tulsa Counties and has the highest cancer toxicity-weighted emissions for both counties. Formaldehyde is the highest emitted pollutant with a cancer toxicity factor in Canadian County and has the highest cancer toxicity-weighted emissions for that county.
- Toluene is the highest emitted pollutant with a noncancer toxicity factor in Oklahoma and Tulsa Counties, while xylenes are the highest emitted pollutant with a noncancer toxicity factor in Canadian County. Acrolein has the highest noncancer toxicity-weighted emissions for all three counties.

Rhode Island.

- The Rhode Island monitoring site (PRRI) is located in Providence and is a NATTS site.
- PAHs and hexavalent chromium were sampled for at PRRI, although sampling for hexavalent chromium was discontinued at the end of June.
- Three pollutants failed screens for PRRI, although greater than 95 percent of failed screens were attributable to naphthalene. As a result, naphthalene is PRRI's only pollutant of interest.
- Naphthalene concentrations measured at PRRI span an order of magnitude, ranging from 17.5 ng/m³ to 187 ng/m³.
- Sampling for the site-specific pollutants of interest has occurred at PRRI for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Although concentrations of naphthalene exhibit little change over the years of sampling, several of the statistical parameters calculated are at a minimum for 2013.
- The cancer risk approximation for naphthalene for PRRI is 2.09 in-a-million. The noncancer hazard approximation for this pollutant is considerably less than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Providence County, while formaldehyde has the highest cancer toxicity-weighted emissions. Toluene is the highest emitted pollutant with a noncancer toxicity factor, while acrolein has the highest noncancer toxicity-weighted emissions for Providence County.

South Carolina.

- The South Carolina monitoring site (CHSC) is located near Chesterfield and is a NATTS site.
- Hexavalent chromium and PAHs were sampled for at CHSC, although hexavalent chromium sampling was discontinued in June.
- Naphthalene was the only pollutant to fail screens for CHSC. Less than 4 percent of naphthalene concentrations failed screens for CHSC.
- Naphthalene concentrations measured at CHSC range from 4.46 ng/m³ to 51.8 ng/m³. Compared to other NMP sites sampling this pollutant, CHSC has the second lowest annual average concentration of naphthalene.
- Sampling for the site-specific pollutants of interest has occurred at CHSC for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific

pollutant of interest. Concentrations of naphthalene measured at CHSC in 2013 are the lowest since the onset of sampling in 2008.

- The cancer risk approximation for naphthalene for CHSC is less than 1.0 in-a-million. The noncancer hazard approximation for this pollutant is considerably less than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Chesterfield County while formaldehyde has the highest cancer toxicity-weighted emissions. Toluene is the highest emitted pollutant with a noncancer toxicity factor, while acrolein has the highest noncancer toxicity-weighted emissions.

Texas.

- There are two NATTS sites in Texas: one in Deer Park (CAMS 35) and one in Karnack (CAMS 85).
- Hexavalent chromium was sampled for at both CAMS 35 and CAMS 85, although sampling was discontinued at both sites in June.
- Hexavalent chromium failed 8 percent of screens for CAMS 35. Because hexavalent chromium did not fail any screens for CAMS 85, this site has no pollutants of interest.
- Concentrations of hexavalent chromium measured at CAMS 35 ranged from 0.0167 ng/m³ to 0.38 ng/m³, including five non-detects. The maximum hexavalent chromium concentration for the program was measured at CAMS 35. Due to the discontinuation of sampling, an annual average concentration could not be calculated.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Harris County, while 1,3-butadiene has the highest cancer toxicity-weighted emissions. Formaldehyde is the highest emitted pollutant with a cancer toxicity factor in Harrison County and has the highest cancer toxicity-weighted emissions.
- Toluene is the highest emitted pollutant with a noncancer toxicity factor in both counties, while acrolein has the highest noncancer toxicity-weighted emissions.

Utah.

- The NATTS site in Utah (BTUT) is located in Bountiful, north of Salt Lake City.
- VOCs, carbonyl compounds, SNMOCs, PAHs, metals (PM₁₀), and hexavalent chromium were sampled for at BTUT. This site is one of only two NMP sites sampling all six pollutant groups. Hexavalent chromium sampling was discontinued in June.

- Twenty-one pollutants failed screens for BTUT, 13 of which contributed to 95 percent of this site's failed screens.
- Of the site-specific pollutants of interest, dichloromethane has the highest annual average concentration for BTUT, which is consistent with previous years of sampling. BTUT has the highest annual average concentrations of ethylbenzene, formaldehyde, and acetaldehyde among NMP sites sampling these pollutants. BTUT also has the second highest annual average concentration of arsenic among NMP sites sampling metals (PM₁₀).
- Sampling for the site-specific pollutants of interest has occurred at BTUT for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. The most notable trend is for benzene. Concentrations of benzene have an overall decreasing trend at BTUT. The 1-year average concentration for 2013 is the lowest 1-year average concentration of benzene calculated since the onset of sampling at BTUT. Additionally, concentrations of acetaldehyde, formaldehyde, and propionaldehyde exhibited significant increases in 2013.
- The pollutant with the highest cancer risk approximation for BTUT is formaldehyde; this is the highest cancer risk approximation calculated across the program and the only one greater than 100 in-a-million. None of the pollutants of interest have noncancer hazard approximations greater than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Davis County and has the highest cancer toxicity-weighted emissions. Toluene is the highest emitted pollutant with a noncancer toxicity factor, while acrolein has the highest noncancer toxicity-weighted emissions for Davis County.

Vermont.

- Two Vermont monitoring sites are located in or near Burlington (BURVT and UNVT); a third monitoring site is located in Rutland (RUVT). UNVT is a NATTS site, while the remaining sites are UATMP sites.
- VOCs were sampled for year-round at BURVT and RUVT. VOCs, hexavalent chromium, PAHs, and metals (PM₁₀) were sampled for at UNVT, although hexavalent chromium sampling was discontinued in June. Sampling at UNVT occurred on a 1-in-6 day sampling schedule while the other two sites sampled on a 1-in-12 day sampling schedule.
- Eight pollutants failed screens for BURVT; six pollutants failed screens for RUVT; and nine pollutants failed screens for UNVT.
- Benzene has the highest annual average concentrations for BURVT and RUVT, while carbon tetrachloride has the highest annual average concentration for UNVT.

- Annual average concentrations for several of the pollutants of interest for UNVT are among the lowest compared to other NMP sites sampling the same pollutants.
- Sampling for several of the site-specific pollutants of interest has occurred at the Vermont sites for at least 5 consecutive years; thus, a trends analysis was conducted where applicable. The most notable trend for the Vermont sites is for 1,2-dichloroethane, a pollutant of interest for all three sites. The detection rate of 1,2-dichloroethane has increased significantly over the years at each of the Vermont sites, particularly in the last 2 years.
- Benzene and carbon tetrachloride have the highest cancer risk approximations for each of the Vermont monitoring sites (although not necessarily in that order). None of the noncancer hazard approximations for these sites are greater than an HQ of 1.0.
- Benzene and formaldehyde are the highest emitted pollutants with a cancer toxicity factors in Chittenden and Rutland Counties. Benzene and formaldehyde also have the highest cancer toxicity-weighted emissions for Rutland County while the order is reversed for Chittenden County.
- Toluene is the highest emitted pollutant with a noncancer toxicity factor in both Vermont counties, while acrolein has the highest noncancer toxicity-weighted emissions.

Virginia.

- The NATTS site in Virginia is located near Richmond (RIVA).
- PAHs and hexavalent chromium were sampled for at RIVA.
- Naphthalene was the only pollutant to fail screens for RIVA, with greater than 96 percent of naphthalene measurements collected at RIVA failing screens.
- Naphthalene concentrations measured at RIVA range from 18.0 ng/m³ to 354 ng/m³. Compared to other NMP sites sampling this pollutant, RIVA has the eighth highest annual average concentrations of naphthalene.
- Sampling for PAHs has occurred at RIVA for at least 5 consecutive years; thus, a trends analysis was conducted for naphthalene. No significant trend in the concentrations of naphthalene measured at RIVA was noted.
- The cancer risk approximation for naphthalene at RIVA is 2.95 in-a-million, while the noncancer hazard approximation is significantly less than a HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Henrico County, while formaldehyde has the highest cancer toxicity-weighted emissions.

- Toluene is the highest emitted pollutant with a noncancer toxicity factor in Henrico County, while acrolein has the highest noncancer toxicity-weighted emissions.

Washington.

- The NATTS site in Washington is located in Seattle (SEWA).
- VOCs, carbonyl compounds, PAHs, metals (PM₁₀), and hexavalent chromium were sampled for at SEWA, although hexavalent chromium sampling was discontinued in June.
- Fourteen pollutants failed screens for SEWA, of which nine were identified as pollutants of interest for this site.
- None of the site-specific pollutants of interest for SEWA have annual average concentrations greater than 1 µg/m³. Acetaldehyde and carbon tetrachloride have the highest annual average concentrations for this site. The annual average concentration of formaldehyde for SEWA is the lowest among NMP sites sampling this pollutant.
- SEWA has the second highest annual average concentration of nickel among NMP sites sampling metals (PM₁₀). This was also true for 2012. This site had the highest annual average nickel concentration for 2010 and 2011.
- Sampling for the site-specific pollutants of interest has occurred at SEWA for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Benzene has an overall decreasing trend at SEWA since the onset of sampling. In addition, the detection rate of 1,2-dichloroethane at SEWA has been increasing steadily over the last few years of sampling.
- Formaldehyde has the highest cancer risk approximation for SEWA, although it is the lowest cancer risk approximation for formaldehyde among NMP sites. All of the noncancer hazard approximations for the pollutants of interest for SEWA are less than an HQ of 1.0.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in King County while formaldehyde has the highest cancer toxicity-weighted emissions. Toluene is the highest emitted pollutant with a noncancer toxicity factor in King County, while acrolein has the highest noncancer toxicity-weighted emissions.

Wisconsin.

- One Wisconsin monitoring site is located in Horicon (HOWI) and is a NATTS site. The second site (MIWI) is located in Milwaukee and is a UATMP site.
- Hexavalent chromium was sampled for at both HOWI and MIWI. Hexavalent chromium sampling was discontinued in March at MIWI at the completion of a

1-year study beginning in 2012. Hexavalent chromium sampling was also discontinued at HOWI in June 2013.

- Thirty hexavalent chromium samples were collected at HOWI prior to the discontinuation of sampling. This pollutant was detected in only four of the samples collected at HOWI and did not fail any screens. Concentrations of hexavalent chromium measured at HOWI in 2013 range from 0.0088 ng/m³ to 0.019 ng/m³ (as well as 26 non-detects).
- Eleven hexavalent chromium samples were collected at MIWI prior to the discontinuation of sampling. This pollutant was detected in eight of the samples collected at MIWI and did not fail any screens. Concentrations of hexavalent chromium measured at MIWI in 2013 range from 0.0033 ng/m³ to 0.0405 ng/m³ (as well as three non-detects). These measurements represent a decrease in the magnitude of the concentrations compared to those measured during the first 9 months of sampling in 2012.
- Benzene is the highest emitted pollutant with a cancer toxicity factor in Dodge County while formaldehyde has the highest cancer toxicity-weighted emissions. Benzene is also the highest emitted pollutant with a cancer toxicity factor in Milwaukee County, while hexavalent chromium has the highest cancer toxicity-weighted emissions.
- Toluene is the highest emitted pollutant with a noncancer toxicity factor in Dodge and Milwaukee Counties, while acrolein has the highest noncancer toxicity-weighted emissions for each county.

32.1.3 Composite Site-level Results Summary

- Twenty-seven pollutants were identified as site-specific pollutants of interest, based on the risk-based screening process. Benzene and 1,3-butadiene were the two most common pollutants of interest among the monitoring sites. Benzene was identified as a pollutant of interest for all 39 sites that sampled this pollutant (with Method TO-15 or SNMOC) and 1,3-butadiene was a pollutant of interest for all but one (BRCO is the exception). Acetaldehyde and formaldehyde were the most common carbonyl compound pollutants of interest. These two compounds were identified as pollutants of interest for all 33 sites that sampled carbonyl compounds. Twenty-three of the 25 sites that sampled PAHs had naphthalene as a pollutant of interest (with GLKY and UNVT as the exceptions). Arsenic was identified as a pollutant of interest for all 20 sites that sampled metals.
- Hexavalent chromium was identified as a pollutant of interest for only two sites (SDGA and CAMS 35), although this is the only pollutant sampled for at these sites. Hexavalent chromium concentrations from several sites (CAMS 85, HOWI, MIWI, and STMN) did not fail any screens, although this was the only pollutant sampled for at these sites. EPA dropped the requirement to sample hexavalent chromium under the NATTS program beginning in July 2013, so all but two of the NATTS sites stopped sampling this pollutant in either June or July.

- Several pollutants were identified as site-specific pollutants of interest for only one or two sites. For instance, dichloromethane is a pollutant of interest for only BTUT; bromomethane is a pollutant of interest for only CSNJ; trichloroethylene is a pollutant of interest for only SPIL; and xylenes are a pollutant of interest for only KMMS.
- Table 32-1 summarizes which pollutants of interest were identified for each site, how many pollutants of interest were identified for each site, and how many sites for which each pollutant was identified as a pollutant of interest.
- Formaldehyde frequently had the highest site-specific annual average concentration among the site-specific pollutants of interest; formaldehyde had the highest annual average concentration for 24 sites. Naphthalene had the next highest at 11 followed by benzene with eight.
- Formaldehyde tended to have the highest cancer risk approximations on a site-specific basis. The cancer risk approximation calculated for BTUT (104.6 in-a-million) from the annual average concentration of formaldehyde is the highest of all annual average-based cancer risk approximations and the only one greater than 100 in-a-million. This site also had the highest cancer risk approximation in the 2012 report, but the cancer risk approximation for 2012 was half as high. Five other sites also have cancer risk approximations greater than 50 in-a-million, four for formaldehyde (GPCO, CSNJ, ELNJ, and PXSS) and one for 1,2-dichloroethane (TVKY). Benzene and 1,3-butadiene are the only other pollutants for which a cancer risk approximation greater than 10 in-a-million was calculated.
- Carbon tetrachloride often had relatively high cancer risk approximations (based on annual average concentrations) compared to other pollutants of interest among the monitoring sites, ranging between 3 in-a-million and 7 in-a-million, but tended to have relatively low emissions and toxicity-weighted emissions according to the NEI. This pollutant appears only once in the emissions-based tables for counties with NMP sites (Marshall County, Kentucky, where the five Calvert City sites are located).
- None of the noncancer hazard approximations were greater than an HQ of 1.0. The noncancer hazard approximation calculated for BTUT's annual average concentration of formaldehyde (with an HQ of 0.82) is the highest of all annual average-based noncancer hazard approximations. Formaldehyde tended to have the highest noncancer hazard approximations on a site-specific basis, followed by 1,3-butadiene and naphthalene.
- Of those pollutants with cancer UREs, benzene, formaldehyde, and ethylbenzene often had the highest county-level emissions for participating counties. Formaldehyde, benzene, and 1,3-butadiene typically had the highest toxicity-weighted emissions (of those with a cancer URE).

Table 32-1. Summary of Site-Specific Pollutants of Interest

State	Site	# of Pollutants of Interest	Acenaphthene	Acetaldehyde	Arsenic	Benzene	Benzo(a)pyrene	Bromomethane	1,3-Butadiene	Cadmium	Carbon Tetrachloride	p-Dichlorobenzene	1,2-Dichloroethane	Dichloromethane	Ethylbenzene	Fluoranthene	Fluorene	Formaldehyde	Hexachloro-1,3-butadiene	Hexavalent Chromium	Lead	Manganese	Naphthalene	Nickel	Propionaldehyde	1,1,2-Trichloroethane	Trichloroethylene	Vinyl chloride	Xylenes
AK	ANAK	8				X			X		X	X	X		X				X				X						
AZ	PXSS	10		X	X	X			X		X	X	X		X			X					X						
AZ	SPAZ	6				X			X		X	X	X		X														
CA	CELA	4	X				X										X						X						
CA	LBHCA	1															X						X						
CA	RUCA	1																					X						
CA	SJJCA	3			X																		X	X					
CO	BMCO	5		X		X			X						X			X											
CO	BRCO	3		X		X												X											
CO	GPCO	12	X	X		X	X		X		X		X		X		X	X	X				X						
CO	PACO	4		X		X			X									X											
CO	RFCO	4		X		X			X									X											
CO	RICO	5		X		X			X						X			X											
DC	WADC	1																					X						
FL	AZFL	2		X														X											
FL	ORFL	2		X														X											
FL	PAFL	1			X																								
FL	SKFL	3		X														X					X						
FL	SYFL	3		X														X					X						
FL	WPFL	4	X													X	X						X						
GA	SDGA	1																		X									
IL	NBIL	11	X	X	X	X			X		X		X			X	X	X					X						

BOLD ITALICS = EPA-designated NATTS Site

Table 32-1. Summary of Site-Specific Pollutants of Interest (Continued)

State	Site	# of Pollutants of Interest	Acenaphthene	Acetaldehyde	Arsenic	Benzene	Benzo(a)pyrene	Bromomethane	1,3-Butadiene	Cadmium	Carbon Tetrachloride	p-Dichlorobenzene	1,2-Dichloroethane	Dichloromethane	Ethylbenzene	Fluoranthene	Fluorene	Formaldehyde	Hexachloro-1,3-butadiene	Hexavalent Chromium	Lead	Manganese	Naphthalene	Nickel	Propionaldehyde	1,1,2-Trichloroethane	Trichloroethylene	Vinyl chloride	Xylenes
IL	ROIL	8		X		X			X		X		X		X			X	X										
IL	SPIL	8		X		X			X		X		X					X	X								X		
IN	INDEM	2		X														X											
IN	WPIN	2		X														X											
KY	ASKY	6		X		X			X		X		X					X											
KY	ASKY-M	5			X					X											X	X		X					
KY	ATKY	5				X			X		X		X											X				X	
KY	BAKY	2			X																			X					
KY	BLKY	7				X			X		X		X						X							X		X	
KY	CCKY	6			X	X			X		X		X						X										
KY	GLKY	7		X	X	X			X		X		X					X											
KY	LAKY	6				X			X		X		X						X									X	
KY	LEKY	8		X	X	X			X		X		X					X	X										
KY	TVKY	8				X			X		X	X	X						X							X		X	
MA	BOMA	3			X																		X	X					
MI	DEMI	10	X	X		X			X		X		X		X		X	X					X						
MN	STMN	0																											
MO	S4MO	15	X	X	X	X			X	X	X	X	X				X	X	X		X		X	X					
MS	KMMS	10	X			X			X		X	X	X		X		X						X						X
MS	SSMS	7				X			X		X	X	X		X				X										
NJ	CHNJ	7		X		X			X		X		X					X	X										
NJ	CSNJ	10		X		X		X	X		X		X		X			X	X						X				

BOLD ITALICS = EPA-designated NATTS Site

Table 32-1. Summary of Site-Specific Pollutants of Interest (Continued)

State	Site	# of Pollutants of Interest	Acenaphthene	Acetaldehyde	Arsenic	Benzene	Benzo(a)pyrene	Bromomethane	1,3-Butadiene	Cadmium	Carbon Tetrachloride	p-Dichlorobenzene	1,2-Dichloroethane	Dichloromethane	Ethylbenzene	Fluoranthene	Fluorene	Formaldehyde	Hexachloro-1,3-butadiene	Hexavalent Chromium	Lead	Manganese	Naphthalene	Nickel	Propionaldehyde	1,1,2-Trichloroethane	Trichloroethylene	Vinyl chloride	Xylenes
NJ	ELNJ	8		X		X			X		X		X		X			X	X										
NJ	NBNJ	7		X		X			X		X		X					X	X										
NY	<i>BXNY</i>	3	X														X						X						
NY	<i>ROCH</i>	4	X												X	X							X						
OK	ADOK	8		X	X	X			X		X	X	X					X											
OK	OCOK	10		X	X	X			X		X	X	X		X			X	X										
OK	TMOK	10		X	X	X			X		X	X	X		X			X	X										
OK	TOOK	11		X	X	X			X		X		X		X			X	X			X		X					
OK	TROK	10		X	X	X			X		X		X		X			X	X					X					
OK	YUOK	8		X	X	X			X		X		X					X	X										
RI	<i>PRRI</i>	1																					X						
SC	<i>CHSC</i>	1																					X						
TX	<i>CAMS 35</i>	1																		X									
TX	<i>CAMS 85</i>	0																											
UT	<i>BTUT</i>	13		X	X	X			X		X	X	X	X	X			X					X	X	X				
VA	<i>RIVA</i>	1																					X						
VT	BURVT	6				X			X		X	X	X						X										
VT	RUVT	5				X			X		X		X		X														
VT	<i>UNVT</i>	5			X	X			X		X		X																
WA	<i>SEWA</i>	9		X	X	X			X		X		X					X					X	X					
WI	<i>HOWI</i>	0																											
WI	MIWI	0																											
Total		357	9	33	20	39	2	1	38	2	34	12	34	1	18	3	9	33	21	2	2	2	23	9	2	2	1	4	1

BOLD ITALICS = EPA-designated NATTS Site

- Of those pollutants with a noncancer RfC, toluene, xylenes, and ethylene glycol were often the highest emitted pollutants, although they rarely had the highest toxicity-weighted emissions. Acrolein tended to have the highest toxicity-weighted emissions of pollutants with noncancer RfCs, although acrolein emissions were generally low when compared to other pollutants. Acrolein appears only twice among the highest emitted pollutants for counties with NMP sites (Garfield County, Colorado and Canadian County, Oklahoma). However, due to the high toxicity of this pollutant, even low emissions translated into high noncancer toxicity-weighted emissions; the toxicity-weighted value was often several orders of magnitude higher than other pollutants. Acrolein is a national noncancer risk driver according to NATA. Besides acrolein, formaldehyde and 1,3-butadiene tended to have the highest toxicity-weighted emissions among the pollutants with noncancer RfCs.
- For the 2013 NMP report, emissions data provided are from version 2 of the 2011 NEI while emissions data for the 2012 NMP report were from version 1 of the 2011 NEI, which explains some changes in the emissions data used to create the point source emissions maps and the risk-based emissions assessment tables.
- Although production of carbon tetrachloride has declined sharply over the last 30 years due to its role as an ozone depleting substance, it has a relatively long atmospheric lifetime and thus, is present at similar levels at nearly any given location. NMP sites are located in a variety of locations across the county with different purposes behind the monitoring at each site. In most cases, the concentrations of carbon tetrachloride measured across the program confirm the ubiquitous nature of this pollutant. However, carbon tetrachloride measurements collected at the Calvert City, Kentucky sites were often higher than levels of this pollutant collected elsewhere. Vinyl chloride is an industrial-marker and is rarely measured at detectable levels (this pollutant has a 13 percent detection rate across the program). The five Calvert City, Kentucky sites together account for more than 67 percent of the measured detections of vinyl chloride for 2013. Individually, these sites have the highest number of measured detections among NMP sites sampling VOCs. The Calvert City sites also account for the 76 highest concentrations of 1,2-dichloroethane measured across the program. These ambient air measurements agree with corresponding emissions data in the NEI. These three pollutants appear among the highest emitted pollutants in Marshall County, Kentucky (among those with a cancer URE) but are not one of the highest emitted pollutants for any other county with an NMP site. From a quantitative standpoint, the emissions of carbon tetrachloride and vinyl chloride in Marshall County are higher than their emissions for any other county with an NMP site. The emissions of 1,2-dichloroethane for Marshall County rank second highest (behind only Harris County, Texas).
- For every NMP site for which 1,2-dichloroethane is a pollutant of interest (34 sites), and where a trends analysis could be conducted for this pollutant, a dramatic increase in the number of measured detections is shown over the most recent years of sampling, particularly for 2012, which was mostly sustained for 2013. This pollutant was detected in less than 10 percent of samples at most sites participating in the NMP prior to 2010 (and still participating now); the rate increased significantly since,

slowly at first then significantly in 2012. The detection rate of this pollutant is between 75 percent and 100 percent for most NMP sites for 2013.

32.1.4 Data Quality Results Summary

Completeness, precision, and accuracy were assessed for the 2013 monitoring effort. The quality assessments presented in this report show that the 2013 monitoring data are of a known and high quality, based on the attainment of the established MQOs.

To the largest extent, ambient air concentration data sets met the MQO for completeness. Only three out of 143 site- and method-specific data sets failed to comply with the MQO of 85 percent completeness while 63 data sets achieved 100 percent completeness.

Method (sampling and analytical) precision and analytical precision were determined for the 2013 NMP monitoring efforts using CV calculations based on duplicate, collocated, and replicate samples. Method precision for each analytical method utilized during the 2013 NMP was within the MQO of 15 percent CV with the exception of hexavalent chromium. Analytical precision for each method was determined to be less than 15 percent CV. The precision calculations presented in this report are based on analytical results greater than or equal to the sample- and pollutant-specific MDL.

Analytical method accuracy is ensured by using proven methods, as demonstrated by third-party analysis of proficiency test audit samples, and following strict quality control and quality assurance guidelines. Most of the pollutants for which audit samples were analyzed met the MQO for accuracy. Of the 37 pollutants analyzed for via audit samples, five exceeded the MQO of ± 25 percent recovery.

32.2 Conclusions

Conclusions extrapolated from the data analyses of the data generated from the 2013 NMP monitoring efforts are presented below.

- A large number of concentrations are greater than their respective risk screening values, particularly for many of the NATTS MQO Core Analytes. For several of the pollutants, all or nearly all of the measurements fail screens. Examples of frequently detected pollutants that typically fail all or nearly all of their screens include benzene, carbon tetrachloride, formaldehyde, acetaldehyde, 1,2-dichloroethane, and 1,3-butadiene. Some of the lesser detected pollutants still fail relatively large numbers

of screens. For example, even though hexachloro-1,3-butadiene was detected relatively infrequently, most of the measured detections failed screens. This is also true for 1,2-dibromoethane and chloroprene.

- Over the last few years, the number of concentrations failing screens has increased, although the percentage of failed screens compared to the number of measured detections has hovered around 36 percent. Yet, for many of the sites that sampled year-round in both 2012 and 2013, the number of failed screens was down for 2013 compared to 2012. Four sites (GPCO, PXSS, S4MO, and TOOK) failed more than 100 fewer screens for 2013 compared to 2012. Aside from these four, the difference in the number of fewer failed screens ranges from one less than in 2012 to 79 fewer failed screens. Only two sites failed more screens in 2013 than in 2012 and one site's number of failed screens did not change at all. The decrease for some sites may be attributable to changes in the risk screening values. The risk screening value for manganese, which typically failed a majority of its of risk screens, was increased by an order of magnitude in the last revision by EPA, resulting in a significant difference between the two reports (from 706 failed screens for 2012 to 61 failed screens for 2013). In addition, the risk screening value for 1,1,2,2-tetrachloroethane was removed altogether. This pollutant accounted for 112 failed screens in the 2012 report. Other changes to the risk screening values include the addition of a risk screening value for coronene (which did not fail any screens) and an update to the dichloromethane risk screening value (which resulted in a relatively small change to the number of failed screens for this pollutant).
- For those pollutants for which annual average concentrations could be calculated and that have available cancer UREs, only one of the cancer risk approximations was greater than 100 in-a-million, which is the first such occurrence since this analysis was added to the NMP report. In total, 38 site- and pollutant-specific cancer risk approximations were greater than 10 in-a-million (28 for formaldehyde, four for benzene, and three each for 1,3-butadiene and 1,2-dichloroethane); and roughly 69 percent were greater than 1.0 in-a-million.
- For those pollutants for which annual average concentrations could be calculated and have available noncancer RfCs, none of the noncancer hazard approximations were greater than an HQ of 1.0.
- When comparing the highest emitted pollutants for a specific county to the pollutants with the highest toxicity-weighted emissions, the pollutants tended to be more similar for the pollutants with cancer UREs than for pollutants with noncancer RfCs. This indicates that pollutants with cancer UREs that are emitted in higher quantities are often more toxic than pollutants emitted in lower quantities; conversely, the highest emitted pollutants with noncancer RfCs are not necessarily the most toxic. For example, toluene is the noncancer pollutant that was emitted in the highest quantities for many NMP counties, and did not rank less than third for any county with an NMP site, but was not one of the pollutants with highest toxicity-weighted emissions for any of these counties. Conversely, while acrolein had the highest noncancer toxicity-weighted emissions for most NMP counties, and ranked second for only one county,

it was among the highest emitted pollutants for only two counties with NMP (and ranked no higher than eighth).

- The number of states and sites participating in the NMP changes from year to year. The number of sites participating in the 2013 NMP increased just slightly, from 64 for 2012 to 66 for 2013. Yet, many of the data analyses utilized in this report require data from year-round (or nearly year-round) sampling. Of the 66 sites whose data are included in the 2013 report, nine sites sampled for an abbreviated duration. This can be due to site initialization and/or site closure/relocation, due to the start or stop date of special studies, such as those related to CSATAM sites, or due to the removal of a pollutant from a list of required pollutants in which to sample, as was the case with hexavalent chromium for the NATTS program. Of the 143 site-method combinations, 30 site-method combinations did not cover the entire year. A majority of these (19) are a result of the delisting of hexavalent chromium, a pollutant that was infrequently identified as a site-specific pollutant of interest. Thus, the number of time-period averages and subsequent risk-based analyses that could not be calculated actually decreased for 2013 compared to 2012. Fewer data gaps allow for more complete results and inter-site comparisons.
- Of the 66 monitoring sites participating in the 2013 NMP, only two sampled for all six available pollutant groups under the national program (BTUT and NBIL). Another four sites (GLKY, PXSS, S4MO, and SEWA) sampled five pollutant groups under the NMP through the national contract laboratory. The wide range of pollutant groups sampled for among the sites, which is often the result of different purposes behind the monitoring at the sites, makes it difficult to draw definitive conclusions regarding air toxics in ambient air in a global manner.
- The data analyses contained in the 2013 NMP report reflect the inclusion of data from a number of source-oriented monitoring sites. The number of such sites has been increasing in recent years. Newer source-oriented sites include several of the Kentucky sites; the two Columbus, Mississippi sites; the Belle Glade, Florida site; and the new Camden, New Jersey site. Many of these sites are the drivers for certain pollutant(s) in the 2013 report. This can easily be seen in the graphical site-specific comparisons to the program-level average concentrations contained in Sections 5 through 31. For many of these pollutants, particularly the VOCs, the highest concentrations were considerably greater than the majority of measurements, such that the scale in the figures needed to be greatly reduced.
- This report strives to represent data derived from the best laboratory practices and utilize the best data analysis techniques available. Examples for 2013 include the improvement of MDLs and the incorporation of updated values for various toxicity factors. This can lead to adjusting the focus of the report to concentrate on the air quality issues of highest concern. Thus, the NMP report is dynamic in nature and scope; yet this approach may prevent the direct comparison of the current report to past reports. Relatively few major changes were instituted between the 2012 and 2013 NMP reports. One difference between the 2013 report and other reports in recent years is the removal of the back trajectory analysis, the coefficient of variation

variability analysis, and the ATSDR MRL screening analysis. Another difference is the inclusion of additional detail in the QA section (Section 31).

32.3 Recommendations

Based on the conclusions from the 2013 NMP, a number of recommendations for future ambient air monitoring efforts are presented below.

- *Continue participation in the National Monitoring Programs.* Ongoing ambient air monitoring at fixed locations can provide insight into long-term trends in air quality and the potential for air pollution to cause adverse health effects among the general population. Therefore, state and local agencies should be encouraged to either 1) develop and implement their own ambient air monitoring programs based on proven, consistent sampling and analysis methods and EPA technical and quality assurance guidance, or 2) consider long-term participation in the NMP.
- *Participate in the National Monitoring Programs year-round.* Many of the analyses presented in the 2013 report require a full year of data to be most useful and representative of conditions experienced at each specified location. Therefore, state and local agencies should be encouraged to implement year-long ambient air monitoring programs in addition to participating in future monitoring efforts.
- *Monitor for additional pollutant groups based on the results of data analyses in the annual report.* The risk-based analysis where county-level emissions are weighted based on toxicity identifies those pollutants whose emissions may result in adverse health effects in a specific area. If a site is not sampling for a pollutant or pollutant group identified as particularly hazardous for a given area, the agency responsible for that site should consider sampling for those compounds.
- *Strive to develop standard conventions for interpreting air monitoring data.* The lack of consistent approaches to present and summarize ambient air monitoring data complicates direct comparisons between different studies. Thought should be given to the feasibility of establishing standard approaches for analyzing and reporting air monitoring data for programs with similar objectives.
- *Continue to identify and implement improvements to the sampling and analytical methods.* In 2012, two analytical methods were accepted by governing bodies as approved methods with which to analyze specific pollutants. ERG's hexavalent chromium method was approved as an ASTM method and ERG's inorganic method for both TSP and PM₁₀ was accepted as a FEM for lead (NAAQS). These approvals were obtained after various method enhancements that improve the detection and recovery of these pollutants. Further research is encouraged to identify other method improvements that would allow for the characterization of an even wider range of components in air pollution and enhance the ability of the methods to quantify all cancer and noncancer pollutants to at least their levels of concern (risk screening concentrations).

- *Revise the pollutants targeted for sampling based on lessons learned in the field, in the laboratory, and/or from the annual report.* In conjunction with method improvements, the analytes targeted for monitoring should/need to be reviewed and revised periodically based on experience with the collection and analysis methods and based on the findings in the annual report. Pollutants initially targeted for ambient monitoring may no longer be considered problematic based on monitoring results and could be discontinued. The removal of hexavalent chromium from the target analyte list for the NATTS program is an example of this. Other pollutants may prove problematic from a sampling and/or analytical stand point and can be removed from the target analyte list due to uncertainties associated with its analytical results. In addition, studies may indicate that one analytical method is better than another at providing accurate results for a given pollutant. All of these factors should be considered when determining the pollutants for which to monitor.
- *Require consistency in sampling and analytical methods.* The development of the NATTS program has shown that there are inconsistencies in collection and analytical methods that make data comparison difficult across agencies. Requiring agencies to use specified and accepted measurement methods, consistent with the guidelines presented in the NATTS TAD, is integral to the identification of trends and measuring the effectiveness of regulation. At the time of this report, the NATTS TAD is undergoing revisions by EPA. When completed and released it is expected that the revised document will enhance method consistency.
- *Perform case studies based on findings from the annual report.* Often, the annual report identifies an interesting tendency or trend, or highlights an event at a particular site(s). For example, dichloromethane concentrations have been highest at BTUT and GPCO for multiple years and trichloroethylene concentrations have been highest at SPIL for multiple years. Further examination of the data in conjunction with meteorological phenomena and potential emissions events or incidents, or further site characterization may help identify state and local agencies pinpoint issues affecting air quality in their area.
- *Consider more rigorous study of the effect of automobile emissions on ambient air quality using multiple years of data.* Because many NMP sites have generated years of continuous data, a real opportunity exists to evaluate the importance and impact of automobile emissions on ambient air quality. Suggested areas of study include additional signature compound assessments and parking lot characterizations.
- *Develop and/or verify HAP and VOC emissions inventories.* State/local/tribal agencies should use the data collected from NMP sites to develop and validate emissions inventories, or at the very least, identify and/or verify emissions sources of concern. Ideally, state/local/tribal agencies would compare the ambient monitoring results with an emissions inventory for source category completeness. The emissions inventory could then be used to develop modeled concentrations useful to compare against ambient monitoring data.
- *Promulgate ambient air standards for HAPs.* Concentrations of several pollutants sampled during the 2013 program year were greater than risk screening values

developed by various government agencies. One way to reduce the risk to human health would be to develop standards similar to the NAAQS for pollutants that frequently exceed published risk screening levels.

- *Incorporate/Update Risk in State Implementation Plans (SIPs).* Use risk calculations to design State Implementation Plans to implement policies that reduce the potential for human health risk. This would be easier to enforce if ambient standards for certain HAPs were developed (refer to above recommendation).

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